POWER

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A HELPING HAND

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Hydro-Electric Plants of the Tennessee Power Co.

By Warren O. Rogers

SYNOPSIS—These two hydro-electric developments have a total capacity of 55,000 hp. The features of No. 1 plant, at Parksville, Tenn., are the 110-ft. high concrete dam, five 5000-hp. turbine waterwheels, and the manner of housing them within the dam. No. 2 development consists of a crib dam 32 ft. high, a wooden flume five miles long supported on a bench, cut in the mountain-side at some places, and at others by trestle work. Two 8-ft. penstocks supply water to two 10,000-hp. waterwheels at a 256-ft. head. Several steam plants are controlled by the company, making a total of 85,000 hp. now available. Additional water power of 115,000 hp. can be developed, as required, making a total of 200,000 hp. available for future use. Electrical energy is transmitted 13½ miles at 66,000 and 120,000 volts to the switch-house at Cleveland, whence it is sent out to several cities.

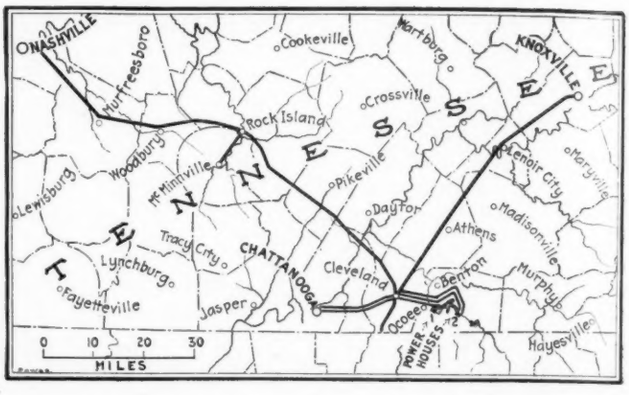


Fig. 1. Transmission Lines and Power-House Sites

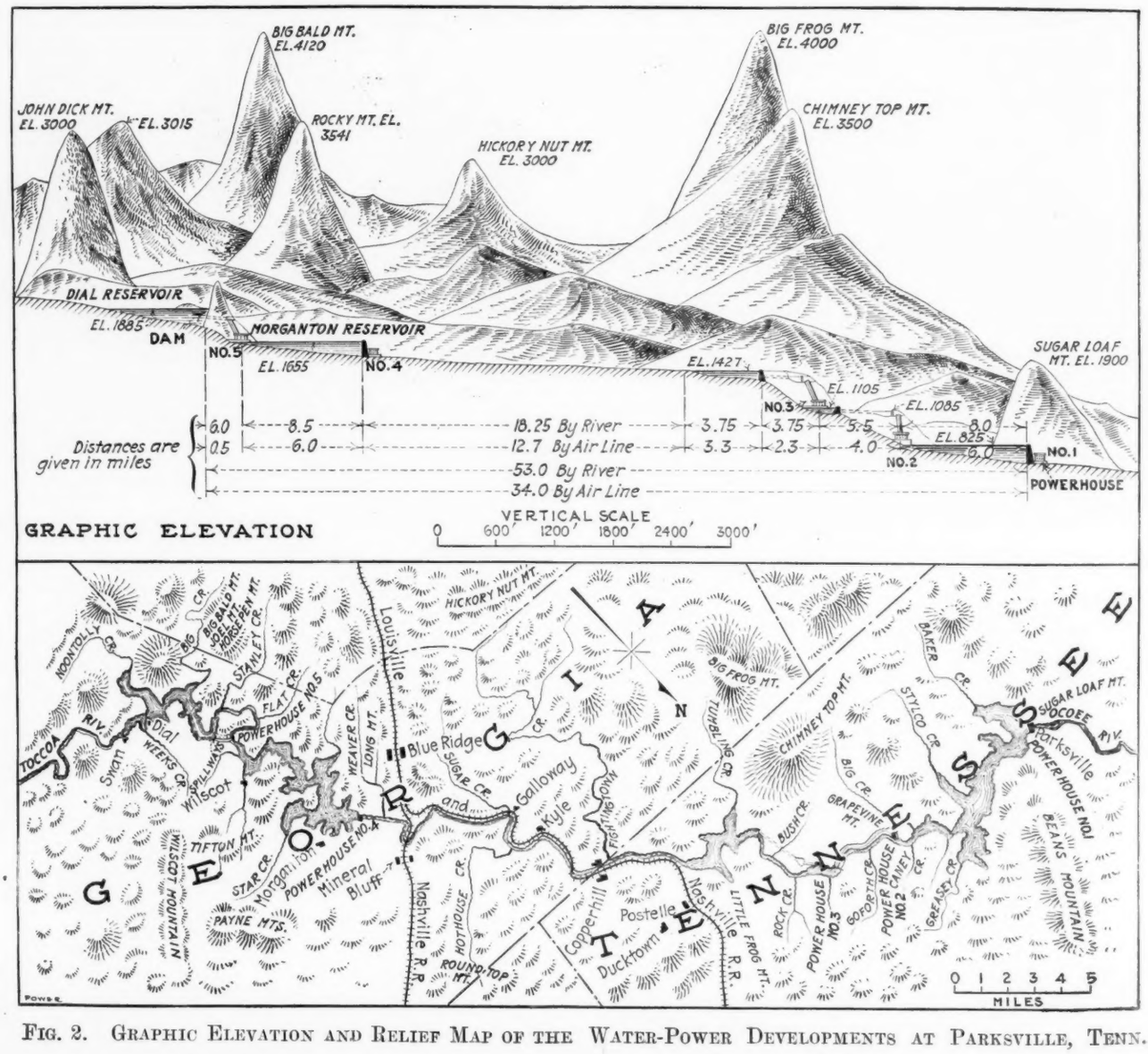


Fig. 2. Graphic Elevation and Relief Map of the Water-Power Developments at Parksville, Tenn.

The second hydro-electric plant of the Tennessee Power Co., on the Ocoee River, in the Appalachian Mountains of southeastern Tennessee, near Parksville, which was put in operation Oct. 23, 1913, marks an important step in the industrial development of that part of the South. This plant, together with the other, 10 miles away, on the same river, will ultimately produce a total of 55,000 hp.

The water resources of the Tennessee Power Co. are principally located between Parksville and Ducktown, on the Ocoee River, in eastern Tennessee, and on the Collins and Caney Fork rivers in middle Tennessee.

It is with the Ocoee River development that this article deals. The river rises in the Appalachian Mountains at an elevation of 2025 ft. above the sea level and has a watershed with an average annual rainfall exceeding that of any other part of the United States excepting Oregon and Washington.

Two miles below Ducktown, the Ocoee River enters a narrow gorge, follows it for 15 miles, then flows through a wide valley to a narrow gateway between Sugar Loaf and Bean Mountains. The waterway between Ducktown and Parksville, a distance of 26 miles, is owned by the company. In this distance the river has a total fall of 710 ft. which will be utilized in three plants, two of which are now in operation. A study of the map, Fig. 1, gives a good idea of the location of the two power sites, the development near Rock Island, and the route of the transmission lines.

In Fig. 2 is shown a graphic elevation and relief map of the three Ocoee developments. At the extreme right is the Parksville dam and the lake formed thereby. The surface of this lake is approximately 2000 acres and is at an elevation of 825 ft. above sea level. Just above the lake is the power house of the No. 2 development. The wooden flume, shown by dotted lines, runs from the dam, five miles above, to the power plant. The third development will consist of a dam and lake 1372 ft. above sea level. It will contain three 10,000-hp. units.

The preliminary work on the two power plants, now completed and in operation, was begun in May, 1910, and actual construction begun in August of the same year. The work was carried on by the Tennessee Power Co., with J. G. White & Co. as engineers. The cost of the two developments was approximately $5,000,000. The main feature of No. 1 development is the concrete dam; that of the other, a five-mile flume built along the mountain-side.

Building a hydro-electric plant is usually more difficult than a steam plant, because of the remoteness of the power site from transportation facilities. The developments on the Ocoee River were no exception. In fact, the conditions were exceptional, and completing these developments was a difficult proposition, both from a financial and an engineering standpoint. For instance, it was necessary to build about seven miles of narrow-gage railroad, operate a fleet of boats and barges to transport the material from No. 1 power plant up the lake, formed by the dam, to the site of No. 2 development. Here an incline was constructed for hoisting material 300 ft. up to the line of the flume. About 15 miles of power-transmission line were also constructed.

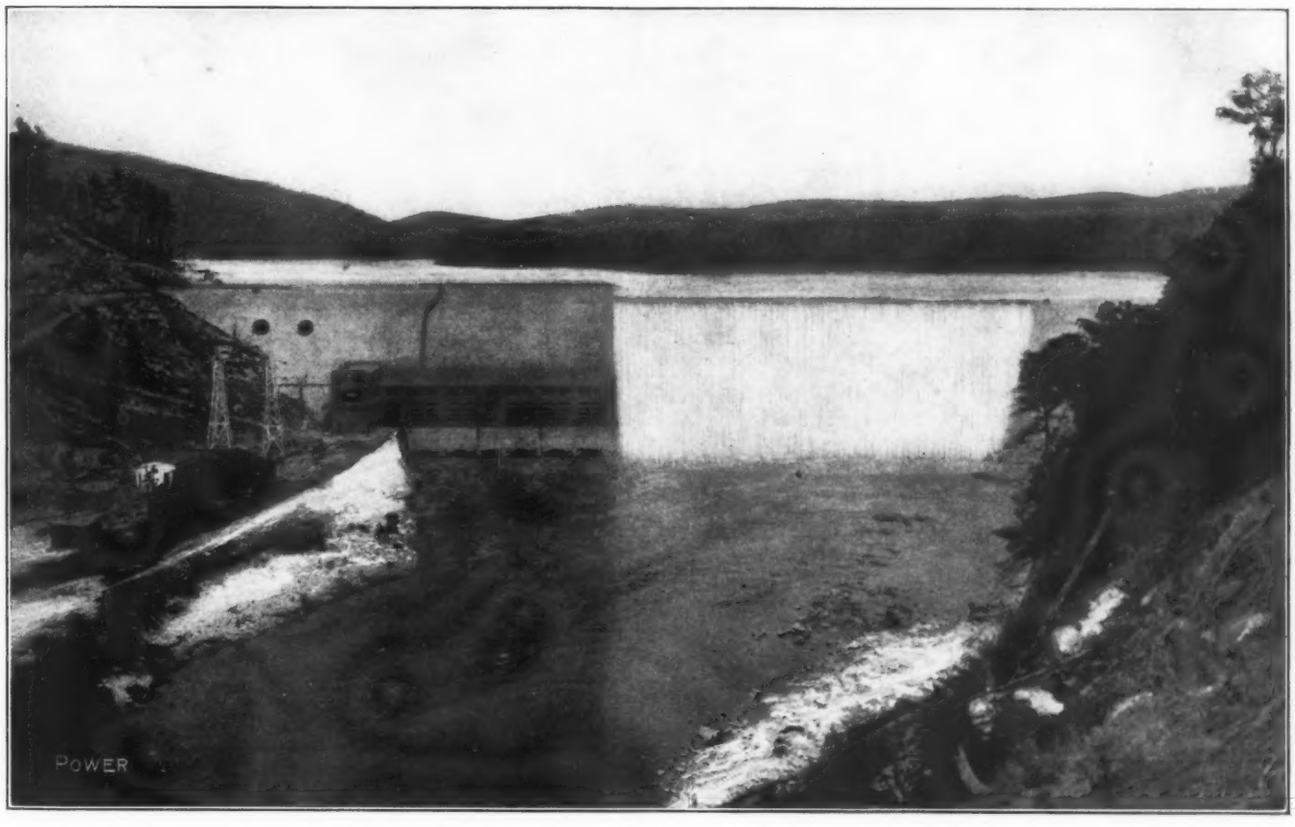


FIG. 3. DAM AND POWER HOUSE OF NO. 1 DEVELOPMENT

Development No. 1, at Parksville, Tenn., consisting of a dam and a generating station, has been in operation two years. The dam, known as a gravity type, is 110 ft. high at the spillway section, and 840 ft. long from bank to bank. The spillway section is 230 ft. long. The structure contains 160,000 cu.yd. of concrete. A view of the dam and power plant is shown in Fig. 3.

The dam is built across a gorge between Sugar Loaf and

Bean Mountains. The spillway is built in an arc of a circle, made necessary because of the formation of the bed rock of the river. The spillway is designed to discharge all excess water at the highest flood stage of the river. In addition to the spillway there are two sluice gates with a discharge capacity equal to the normal flow of the river.

Referring to the sectional view of the dam and power

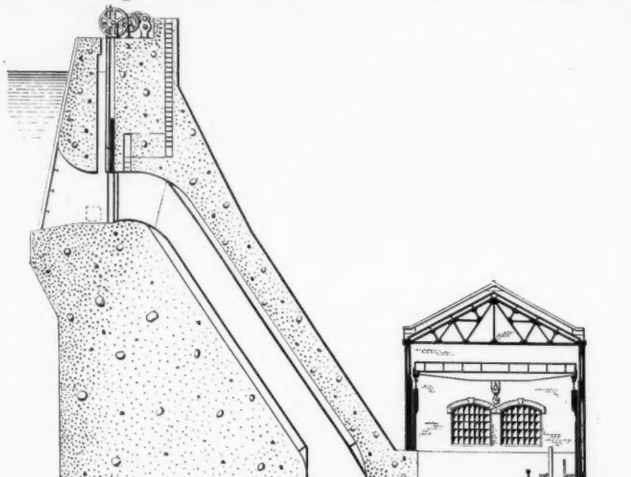


FIG. 4. CROSS-SECTION OF DAM AND POWER HOUSE NO. 1.

house, Fig. 4, the penstocks are encased in the concrete work of the dam and lead to the waterwheels, discharging the water at a point above the wheel vanes. At the rear of the waterwheels a tunnelway has been provided for access to the rear turbine-shaft bearings and to the hand-operated sluice-gate gear. There is a vacuum of 15 in. in the waterwheel draft tubes. The operating mechanism for the double penstock gates is mounted at the top of

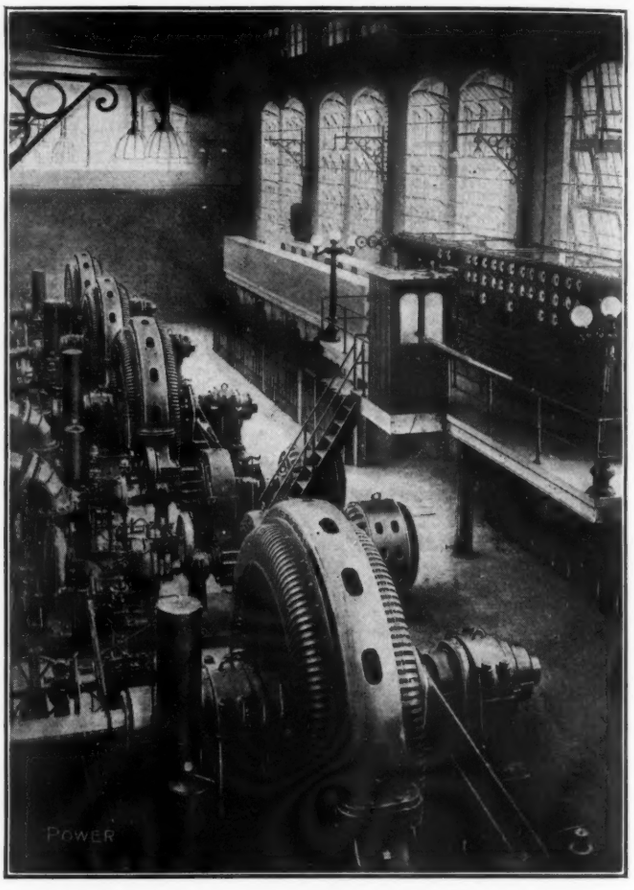


FIG. 5. INTERIOR OF NO. 1 POWER HOUSE

the dam and is operated by 10-hp. direct-current motors, controlled from the power-house switchboard.

No. 1 Power House

The brick building, constructed with an ell, is built parallel with and at the base, at one one end of the dam. The five generators, of 3750 kv.-a. capacity, generating 2300-volt, three-phase, 60-cycle current, are in the main part of the building. The generators are directly connected to the five 5000-hp., horizontal, double-wicket 39-in. gate

FIG. 6. GENERAL VIEW OF CRIB DIVERSION DAM

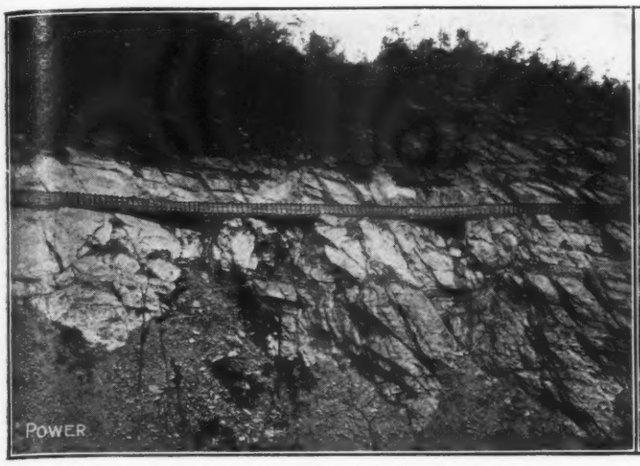


FIG. 7. FLUME ON MOUNTAINSIDE

FIG. 8. STEEL TRESTLE AND FLUME

turbines, which run at 360 r.p.m. Fig. 5 shows the generator room.

The speed of the turbine wheels is governed by oil-pressure-operated governors, equipped with an emergency safety device for closing the inlet water gates in case of accident.

There are two 125-volt exciter sets of 120 kw. capacity, either of which is of sufficient capacity to excite all of the generators; each are driven by 250-hp. wicker-gate waterwheels at 580 r.p.m. Mounted on the end of the shaft of each exciter unit is a 200-hp., 2300-volt induction motor, which floats on the line and gives close regulation to the excitation voltage. As there is a coupling between the turbine and motor and the exciter generator they can be disconnected and the exciter generator operated while either the turbine or the motor is cut out for repairs. The speed of the exciter turbines is regulated by governors of the compensating type.

The generators are at one side of the room, with the shaft extending through the side wall to the turbines, which are outside the building and are housed in the dam. The exciter waterwheels, however, are in the generator room. Riveted-steel penstocks protrude through the side wall and connect with the turbine casings at the top.

On the opposite side is a switchboard balcony, under which are the low-tension oil switches; the distributing busbars are back of them. A brass miniature busbar circuit is attached to the front of the slate-panel switchboard. All switches are provided with a bell alarm and are operated by remote control.

The high-tension transformers, the high-tension room and the office are in the ell of the building. The five 3750-kv.-a., 2300-66,000-volt, three-phase transformers are water cooled. Two gravity sources of water are available for this purpose, one from a spring on the mountain, the other from the lake above the dam. The transformers are in compartments which are fitted with rolling steel doors.

Disconnecting switches are arranged on each side of the high-tension switches; the transformers and busbars are in the high-tension room. Outside of the building there are 16 cells of aluminum lightning arresters. The choke coils are in the high-tension room.

Electrical energy from this station is carried to the Cleveland switch house on two 66,000-volt transmission lines, each line being capable of carrying the output of the station.

DEVELOPMENT NO. 2

The dam at No. 1 development has formed a lake approximately eight miles long and 2000 acres in area. Ten miles above the first development is a second of 30,000-hp. capacity. This plant differs from No. 1, which is of low head and has a large reservoir section. The reservoir at the head of No. 2 dam is only of sufficient size to equalize the flow of water for a short time. The head

FIG. 9. INTERIOR CONSTRUCTION OF THE FLUME

FIG. 10. AUXILIARY SPILLWAY ON MOUNTAINSIDE

FIG. 11. TOP OF FLUME

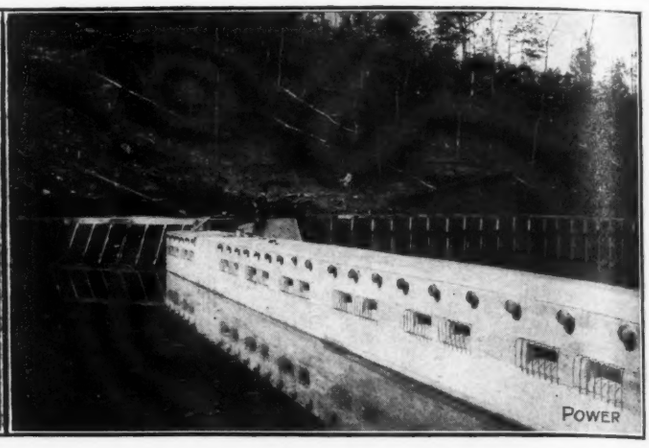


FIG. 12. SIPHON SPILLWAY DAM

available at No. 2 is 256 ft., which is obtained by a diverting dam, five miles above the station and 15 miles above No. 1 dam, and a wooden flume line through which the water flows from the dam along the mountain-side to a point above the station.

Dam No. 2, Fig. 6, is 34 ft. high and 750 ft. long. It is built of heavy timbers, forming cribs, which are filled with rocks and sheathed with heavy lumber. About

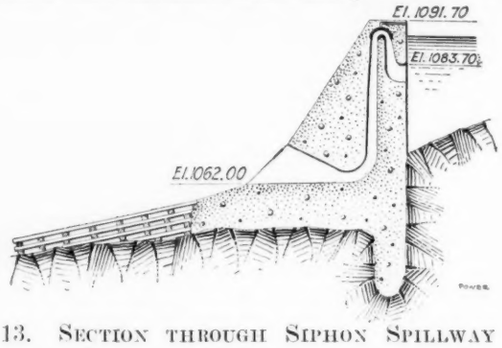


FIG. 13. SECTION THROUGH SIPHON SPILLWAY DAM

1,250,000 ft. of lumber were used. At the southern end of the dam is a large gate which controls the flow of water to the flume.

THE FLUME

The flume, a large wooden trough conveying the water from above the dam to the power house, five miles distant, is 15 ft. wide and 10 ft. high, with a carrying capacity of 550,000 gal. per min. It is supported on a shelf, Fig. 7, cut in the mountain-side. At certain points the flume is supported by viaducts, varying in height from 75 to 150 ft. and in length from 200 to 500 ft. Five of these viaducts are of steel, Fig. 8, and five are of wooden trestles supported by concrete foundations. In the construction of the flume 7,500,000 ft. of lumber were used; Fig. 9 shows the interior construction. There is an auxiliary spillway, Fig. 10, over which the water flows when the stage is high in the flume.

Fig. 11 is a near view of the flume and the top structural work. The track is used for transporting material to points along the flume. At the lower end of the flume the water is discharged into a small concrete regulating reservoir connected to the penstocks by a large section of flume. At this point the flow is regulated by a siphon spillway dam, Fig. 12, which automatically discharges excess water and keeps the flow in the penstock within certain limits. Fig. 13 is a section through the spillway dam. There are two steel penstocks, each 8 ft. in diameter, which convey the water to the turbines in the power house under a head of 256 ft. The electrically operated head gates are controlled from the power house.

NO. 2 POWER HOUSE

The power house, located on Caney Creek, Fig. 14, is 100 ft. long, 80 ft. wide and 55 ft. high, and is constructed of brick, concrete and steel. The power equipment at present consists of two 10,000-hp. turbines, directly connected to 7500-kw., 6600-volt, three-phase, 60-cycle generators running at 360 r.p.m. Provision has

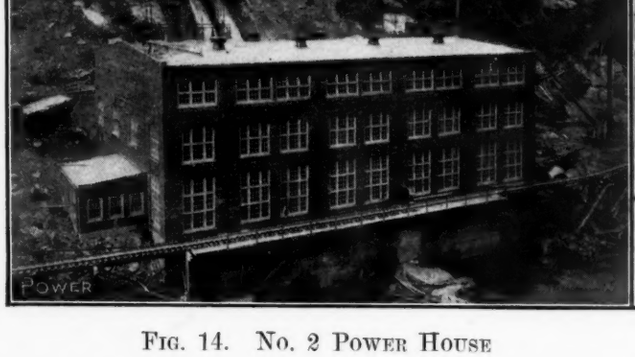


FIG. 14. NO. 2 POWER HOUSE

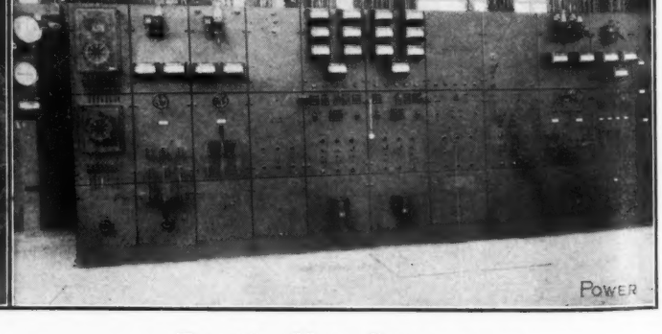


FIG. 15. MAIN SWITCHBOARD

been made for a third penstock and a third 10,000-hp. generating unit.

The generating units, Fig. 16, stand lengthwise of the generator room. On the same floor level are two 9375-kv.-a., three-phase, 60-cycle, 6600-120,000-volt transformers. Back of these on a concrete floor are five oil-break switches, for the machine and transformer low-tension, 6600-volt lines, and one 300-amp. oil switch for station service. There are nine oil switches in three banks, Fig. 17, delta-connected and of 120,000 volts capacity for line control. The station transformers are on a gallery and transform from 6600 to 110 and 220 volts. The four aluminum lightning arresters are of from 115,000 to 125,000 volts capacity. All oil switches are remotely controlled from a 11-panel slate switchboard, Fig. 15.

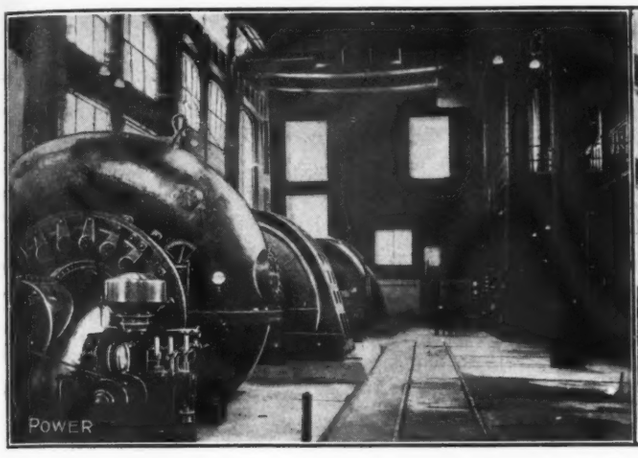


FIG. 16. GENERATOR UNITS, NO. 2 POWER HOUSE

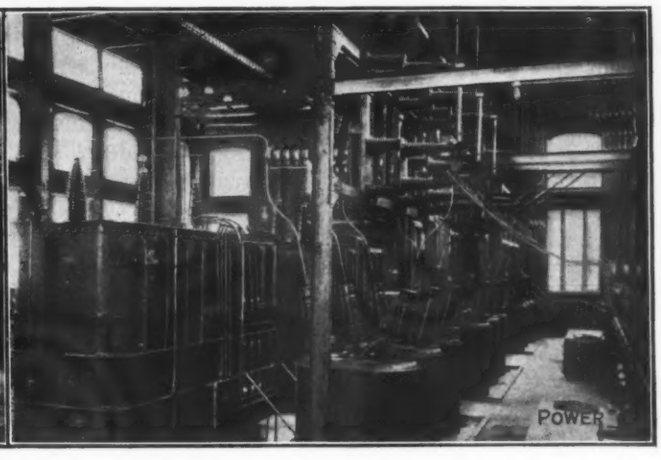


FIG. 17. OIL SWITCHES AND TRANSFORMERS, NO. 2 PLANT

At one end of the room is a 75-hp. motor-driven, 50-kw., 125-volt exciter set running at 1200 r.p.m. This unit is for emergency use, as each main generator has a 125-volt direct-current generator mounted on its shaft. On the other end of each shaft is a brake disk for bringing the rotating parts to rest after shutting off the water supply. At the other end of the generator room are two 10-hp., 900-r.p.m., motor-driven vertical sump pumps for taking care of water which finds its way to the sump from various sources. The 4x6-in. triplex governor oil pumps are belt driven from the generator shaft; the governors are of the double-float lever type.

Nos. 1 and 2 plants will ultimately produce 55,000 hp. A duplicate steel tower line connects No. 2 power house with the Parksville plant, and from this station electrical energy is transmitted to various points on over 400 miles of high-tension lines. The current is transmitted to the distributing station at Cleveland, 13½ miles, at 66,000 and 120,000 volts. From there the current is sent to Chattanooga, Knoxville and Rome over three-phase, 66,000-volt transmission lines, and to Nashville at 120,000 volts. All transmission lines, whether of steel tower or pole type, are of the latest design, metal crossarms being used on pole construction, and suspension-type insulators in all cases. All lines are protected from lightning by a ground wire from the top of the structures.

STEAM PLANTS

The company has acquired by ownership or by contract the output of steam-power plants at Knoxville, Cleveland, Chattannoga, Rome and Nashville, as well as steam plans in smaller intervening towns along the transmission line. The steam plants are connected through substations so as to supply energy to any point on the system; they can also be run in parallel with the water-power plants and carry any proportional part of the load. The present capacity of the steam plants is 30,000 and the water power 55,000 hp. The ultimate water power that can be obtained from three other available power sites will be 115,000 hp., a total of 200,000 hp.

The cost of the two power developments on the Ocoee River was about $5,000,000. A considerable part of the electrical energy developed at these plants is used in lighting the cities along the line and for trolley-car service. The total urban population supplied numbers about 250,000.

PRINCIPAL EQUIPMENT OF THE HYDRO-ELECTRIC PLANTS OF THE TENNESSEE POWER CO., OCOEE RIVER DEVELOPMENTS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Generators	Alt. current	3750 kw	Main units	360 r.p.m., 2300 volts, three-phase, 60-cycle	Westinghouse Elec. & Mfg. Co.
5	Turbines	Horizontal	5000 hp.	Driving main units	360 r.p.m. head 256 ft.	S. Morgan, Smith Co.
5	Governors	Lombard		Main turbines	Oil pressure	Lombard Governor Co.
2	Turbines	Horizontal	250 hp.	Driving exciter gen.	580 r.p.m. head 256 ft.	S. Morgan, Smith Co.
2	Generators	Direct current	120 kw.	Exciters	580 r.p.m., 125 volt	Westinghouse Electric & Mfg. Co
2	Governors	Compensating		Exciter turbines	Oil pressure	Woodward Governor Co.
2	Motors	Induction	200 hp.	Exciters	580 r.p.m., 2300 volt, three phase, 60 cycle	Westinghouse Elec. & Mfg. Co.
5	Transformers	Water cooled	3750 kv.a.	Line circuits	Delta and Star connected, three phase, 60 cycle	Westinghouse Elec. & Mfg. Co.
2	Turbines	Horizontal	10,000 hp.	Driving main units	360 r.p.m., head 256 ft.	I. P. Morris Co.
2	Generators	Alt. current	750 kw.	Main units	6600 volts, three phase, 60 cycle, 360 r.p.m.	General Electric Co.
2	Transformers	Oil cooled	9375 kv.a.	Line circuits	6600—120,000 volt, three-phase, 60-cycle	General Electric Co.
2	Motors	Induction	10 hp.	Sump pumps	Intermittent, 900 r.p.m., 110 volt	Western Electric Co.
1	Generator	Direct current	50 kw.	Exciter	Standby unit, 1200 r.p.m., 125 volt	General Electric Co.
2	Generators	Direct current	50 kw.	Exciters	Mounted on gen. shaft, 360 r.p.m., 125 volt	General Electric Co.
1	Motor	Induction	75 hp.	Driving exciter	220 volt, 1200 r.p.m.	General Electric Co.
2	Governors	Lever		Main turbines	Oil pressure	I. P. Morris Co.
2	Pumps	Plunger	4x6″	Hydraulic governors	Belt driven	Deane Steam Pump Co.

Improvements in English Gas Producers

By Arthur H. Allen

SYNOPSIS—Special features of the Kerpely and Crossley producers tending toward efficient utilization of low-grade coals.

While the modern gas producer is in many respects efficient and satisfactory, there is scope for its improvement, especially as relates to its continuous operation, rendering it as far as possible automatic, and enabling it to deal with low-grade fuel. The following describes some recent innovations in English practice, designed to attain these ends.

Kerpely Producer

The use of a water trough to seal the bottom of a pressure gas producer, while allowing the ashes to be raked out, presents no novelty; but in the Kerpely producer (Fig. 1) the water trough is made to revolve on ball bearings, so that the ashes are carried around against a fixed scraper arranged in a sloping position, which automatically conveys the ashes out of the trough and dumps them into a chute. Taking advantage of the rotary motion provided for this purpose, the inventor designed also a special grate, which is placed eccentrically on the water trough and revolves with it. The grate is elliptical in plan, and its periphery is polygonal, so that, as the grate slowly rotates, it gradually crushes the clinkers, which form at the bottom of the fire, against the apron of the water seal, breaking them up into lumps which fall into the trough and are removed as described. Special provision is also made for the separate control of the steam and air supply to the central and outer portions of the grate, so as to secure uniform combustion over the whole grate. The conical grate is flattened on the top, to keep the CO_2 zone as low as possible. The lower part of the casing consists of a water-cooled jacket, to which the clinker cannot cling as it does to a brick lining. The grate revolves slowly and requires only one or two horsepower to drive it.

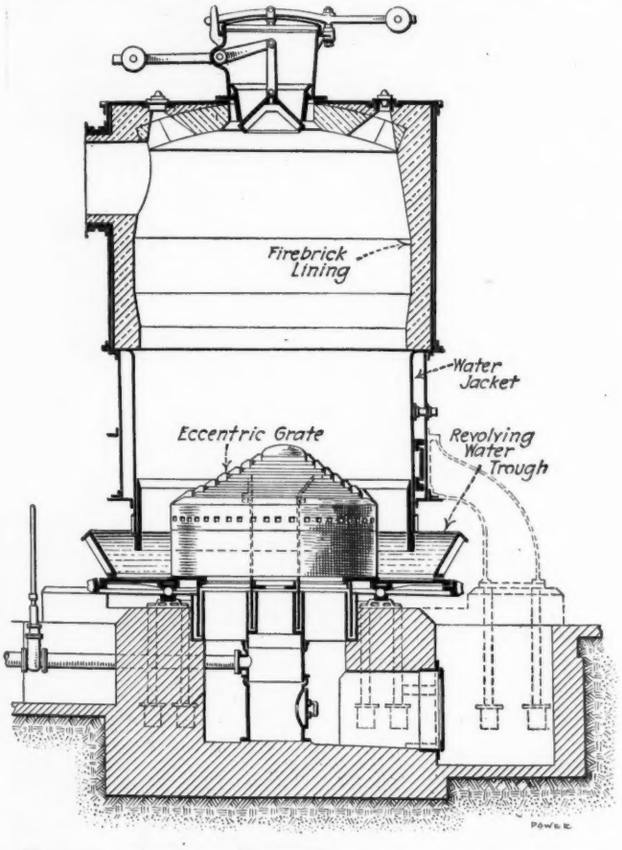


Fig. 1. Kerpely Producer, Showing Revolving Water Trough

Owing to the ability of this producer to gasify coal more rapidly than the ordinary type, a smaller plant suffices to do the same work; the automatic removal of the ashes and the self-clinkering action of the grate reduce labor costs; repairs are also eliminated, and gas of good quality can be obtained from fuel containing as much as 35 per cent. of ash. The gas is also of very uniform composition, owing to the steady and continuous operation of the producer. In the course of a test of one of these plants, at Vienna, gasifying coke breeze, the net efficiency of the producer was found to be 89.8 per cent., 75.37 per cent. of the heat energy of the fuel being made available in the form of gas and 14.43 per cent. being used for the production of steam.

E. G. Appleby & Co., the British agents for the Kerpely producer, have devised a poke hole for use on any pressure producer, which can be opened without allowing gas to escape or air to enter. The hole is provided with compressed-air jets, which are adjusted so as to secure equilibrium between the gas pressure and that of the jets. Thus no gas is lost, and the attendants are able to work without inconvenience from inhalation of the poisonous gas. A still better plan which they have devised is a system of automatic stirring applied to the top of the producer, as shown in Fig. 2. The curved pokers, of different lengths, are provided with pinions gearing with a circular rack, and are carried in a frame attached to the hopper. The top section of the producer is slowly rotated by worm gearing, causing the pokers to travel around the fuel bed, and also rotating on their own axes, so that the upper layers of the fuel are thoroughly stirred, and holes are prevented.

Crossley Suction Producer

In the new producer brought out by Messrs. Crossley Bros. last summer, the difficulties met with in gasifying low-grade fuel are overcome in a totally different manner. As shown in Fig. 3, poke holes *F* are provided in the top of the producer, through which the poker can be introduced in a line parallel to the brickwork and close to it, so that clinker which adheres to the firebrick lining can be loosened without fear of striking the brick, and therefore with the minimum risk of damaging the lining. The fire grate is quite open to the atmosphere, and is composed of a number of stepped plates, of such a diameter and so supported on legs as to stand outside

the natural angle of repose of the fuel. Thus the center of the column of fuel rests upon its own bed of ash, and the bottom of the fire is in full view of the attendant, who can clean every part of the grate and remove clinker and ash, without interfering with the operation of the producer. In the new Crossley type the vaporizer is entirely separate from the producer, simplifying the construction and operation of the producer, and facilitating repairs. It will be seen from the sectional elevation that the construction of the generator is extremely simple, consisting of little more than a casing lined with firebrick.

The vaporizer consists of a cast-iron box *G* through which the hot gas passes on its way to the scrubber, with a water seal at the bottom. The box contains a number of gilled tubes *J*, with internal tubes arranged on the "Field tube" principle, being supported only from the top, so that they are free to expand and contract without risk of breaking joints. Water is led through the internal tube to the bottom of the first gilled tube in which it rises, and overflows at *L* into the internal tube of the next element, passing through all the elements in series; in the last tube *M* it is wholly converted into steam, which is led off to the grate and fed into the fire through a perforated ring *O*. It will be noticed that the water in the tubes is surrounded with a jacket of hot gas, and the vaporizer both cools the gas and raises steam. At the outlet from the vaporizer the gas passes through two cascades of water *P* from the overflow of the scrubber, by which means the heavier impurities are washed out of the gas, and the work required of the scrubber is lessened. From the scrubber the gas is led away to the engine. An induction fan is used instead of a blower for starting the producer, and is placed as close to the engine as possible. This has the advantages that the producer is started as a suction plant instead of under pressure, so that there is no risk of escape of gas; the pipe to the engine is filled with gas, and one man can easily start both the producer and the engine.

An ingenious automatic device is employed to feed water into the vaporizer at the correct rate, to suit the load on the engine. Water is allowed to trickle into the funnel *W*, and when the plant is idle, it is caused by the siphon bend S_1 to escape by the overflow pipe *X*; but when there is a load on the engine, the suction in the gas outlet draws water over the top of the bend S_1, whence it falls into the lower bend *S*, and thence flows into the funnel *K* on the vaporizer. The greater the load on the engine the more rapidly is the water drawn over and fed to the vaporizer, and when once the correct rate of flow has been ascertained, the adjustment is automatic for all loads. Provision is made to allow water to trickle on the grate through the funnels *EE* when starting the producer, so that there is no delay while steam is being raised in the vaporizer. There are no moving parts in the automatic water regulator.

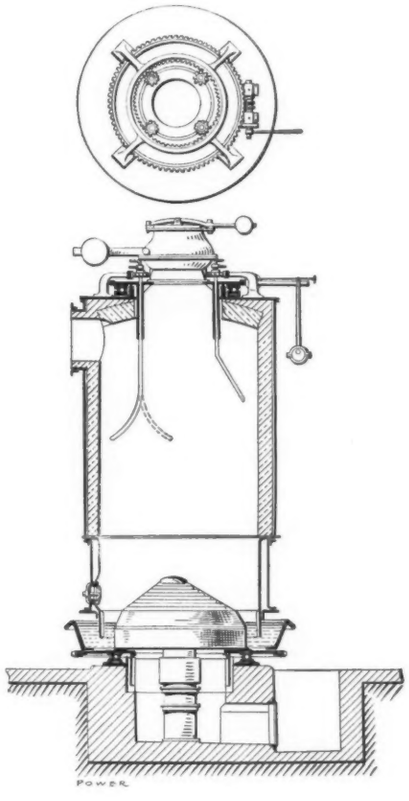


FIG. 2. KERPELY PRODUCER WITH ROTARY POKERS

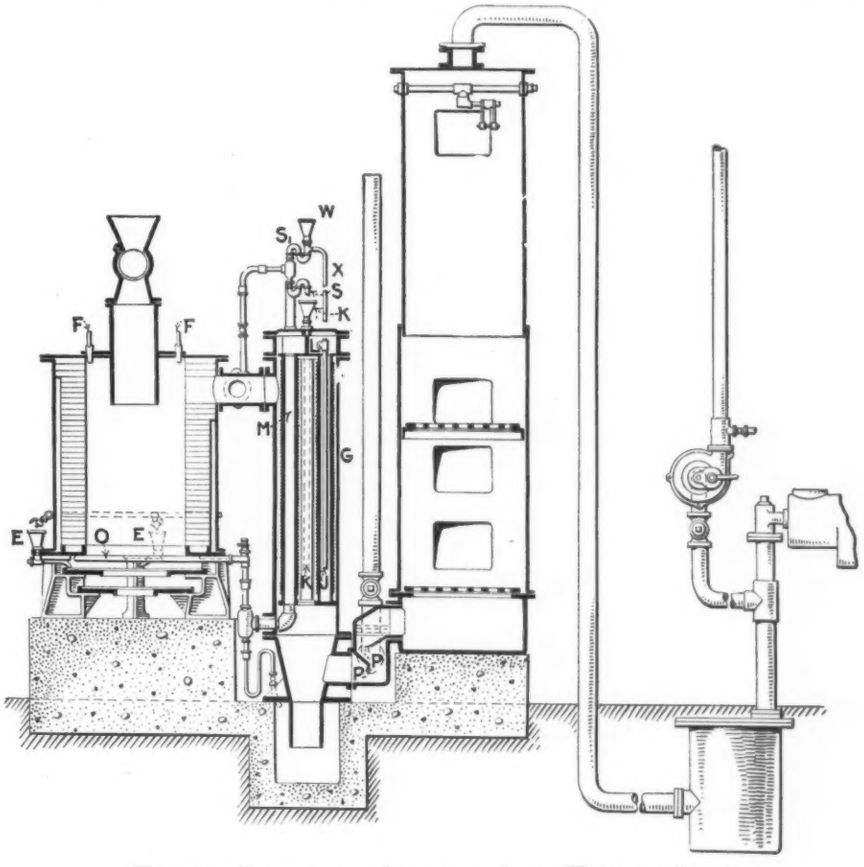


FIG. 3. SECTION OF CROSSLEY OPEN-HEARTH SUCTION PRODUCER

MOORE PRODUCER

The Moore producer differs from the foregoing in that it is designed for byproduct recovery, even in plants having an output as small as 300 hp. For this purpose it is necessary to keep down the temperature of the gas, lest

the ammonia that is formed be decomposed again. This is usually effected by admitting an excess of steam, but in the Moore type the disadvantages of this method are avoided by treating the fuel in three zones: the lowest, a high-temperature zone, in which the bulk of the gas and ammonia are generated; the second, a water-jacketed low-temperature zone, and the third, an air-cooled zone—really a continuation of the second. The temperatures of the three zones are approximately 800-1000 deg. C., 300-450 deg. C., and 180 deg. C., respectively. The tar is extracted in air coolers, and the ammonia is scrubbed out in two washers arranged in series. For a more detailed description of this type of producer, see POWER for Aug. 16, 1913.

Working Up a Boiler Test

By F. R. Low

SYNOPSIS—Explaining the computation of the results of a capacity test. Equivalent evaporation from and at 212 deg. Factors of evaporation. Correcting for moisture, superheat and leakage. Percentage above or below rating.

A boiler test may be made simply to find the capacity of a boiler, or to determine the efficiency, or it may be extended so as to furnish the information needed for an analysis of the performance and to show why it fails to produce desired results.

Test for Capacity

One would naturally say that the capacity of a boiler is measured by the amount of steam which it will make in a given time. This is true—with modifications. The same boiler will make more steam per hour with hot feed water than with cold, it will make more "wet steam" than it will dry or superheated steam, and it will make more (though not so much more, as many think) of low-pressure than of high-pressure steam. In order, then, to determine the real capacity of a boiler it is necessary to know the: *a* duration of the test; *b* amount of water fed to the boiler corrected for difference in level at the beginning and the end of test; *c* temperature of feed water; *d* pressure of steam; *e* quality of steam.

The item *a* is simply the time during which the boiler was run at the capacity which it is sought to measure.

The item *b* is the amount of water which the boiler got rid of, but it may not all have been converted into steam. A part may have been carried over as unevaporated water. To turn out steam which was exactly "dry saturated," which had neither moisture nor superheat would be a feat for a laboratory, so that if the test is to be accurate the quality of the steam, item *e*, must be known. Some of the water may have leaked out, but we will, for simplicity, suppose the boiler and connections to be tight below the water line.

Suppose a capacity test has yielded the following results:

Duration of test	10 hr.
Amount of water fed to boilers corrected for difference in levels	137,642 lb.
Temperature of feed water	196 deg.
Pressure of steam (gage)	122.6 lb.
Quality of steam	96.5%

Of the 137,642 lb. of water fed to the boilers only 96.5 per cent. or

$$137{,}642 \times 0.965 = 132{,}824.53 \text{ lb.}$$

was evaporated; and on an average one-tenth of this or 13,282.453 lb. per hour.

The steam pressure given, 122.6 lb., is the average for the 10 hr. of the test: that is, the way that the fractional pounds come in; not that the gage has been read to tenths of a pound. It is the "gage pressure" or the pressure above that of the atmosphere. The pressures used in the steam tables are absolute pressures, i.e., gage pressures plus the pressure of the atmosphere. At the sea level the pressure of the atmosphere varies around 14.7 lb.; at an elevation it is less. If one has the reading of the barometer during the test he reduces it to pounds per square inch by multiplying the barometric reading in inches of mercury by 0.49 and adds the pressure so found to the gage pressure. In the absence of the barometric reading add the usual pressure of the atmosphere at the place at which the test is made. Suppose the test to be made at the sea level we add

122.6 gage pressure
14.7 atmospheric pressure

137.3 lb. absolute pressure

It will make little difference in the result if we call the average absolute pressure 137 lb., but the values of the properties of steam are given in the table in even degrees as well as in even pounds. It may be possible that the pressure corresponding with some even degree will be 137.3 or nearer to it than 137, the nearest value in the pressure table. The temperature corresponding with 137 lb. is 351.4. Look at this part of the temperature table and find that 351 deg. corresponds with 136.3 lb. and 352 deg. with 138.1 lb. There is nothing between, and neither is nearer the given value 137.3 than the line for 137 lb. on the pressure table.

The table* shows in the "total heat" (H) column that it takes 1191.8 B.t.u. to make a pound of dry-saturated steam of 137-lb. pressure out of a pound of water at 32 deg. Turn to 196 deg. the feed-water temperature in the temperature table and find in the "heat of the liquid" (h) column that it takes 163.92 B.t.u. to raise a pound of water from 32 to 196 deg. This much is already in the feed supplied at 196 deg. The boiler has had to put in the difference,

1191.80 B.t.u. = H at 137 lb.
163.92 B.t.u. = h at 196 deg.

1027.88 B.t.u. required per lb. evaporated from196 at 137 lb.

Water boils at the usual atmospheric pressure, 14.7 lb. absolute, at 212 deg. Look at the temperature table and in the line for 212, seventh column marked "latent heat of evaporation" (L), find the value 970.4. This means that after you get the pound of water up to the boiling point, 212 deg., you have to put 970.4 B.t.u. into it to boil it away. If you had a pound of water in a flask at 32 deg. under 14.7 lb. per sq.in. absolute pressure and applied heat to it, it would take 180 B.t.u. to raise it to 212 deg., when it would commence to boil, and 970.4 B.t.u. or

*The values given are from the Marks-Davis tables

Equivalent Evaporation From and at 212 Degrees

Temperature of Feed Water Degrees Fahrenheit	Pressure of Steam in Pounds Absolute—Dry Saturated												Temperature of Feed Water Degrees Fahrenheit
	15	25	35	45	55	65	75	85	95	105	115	125	
32	1.1858	1.1958	1.2024	1.2073	1.2113	1.2144	1.2171	1.2195	1.2216	1.2234	1.2251	1.2266	32
35	1.1827	1.1927	1.1993	1.2042	1.2081	1.2113	1.2140	1.2164	1.2184	1.2203	1.2219	1.2235	35
40	1.1775	1.1875	1.1941	1.1990	1.2030	1.2062	1.2088	1.2112	1.2133	1.2151	1.2168	1.2183	40
45	1.1723	1.1823	1.1889	1.1939	1.1978	1.2010	1.2037	1.2060	1.2081	1.2099	1.2116	1.2131	45
50	1.1672	1.1772	1.1838	1.1887	1.1926	1.1958	1.1985	1.2009	1.2029	1.2048	1.2064	1.2080	50
55	1.1620	1.1720	1.1786	1.1836	1.1875	1.1907	1.1933	1.1957	1.1978	1.1996	1.2013	1.2028	55
60	1.1569	1.1669	1.1735	1.1784	1.1823	1.1855	1.1882	1.1906	1.1926	1.1945	1.1961	1.1977	60
65	1.1517	1.1617	1.1683	1.1733	1.1772	1.1804	1.1830	1.1854	1.1875	1.1893	1.1910	1.1925	65
70	1.1466	1.1566	1.1632	1.1681	1.1720	1.1752	1.1779	1.1803	1.1823	1.1842	1.1858	1.1874	70
75	1.1414	1.1514	1.1580	1.1630	1.1669	1.1701	1.1728	1.1751	1.1772	1.1790	1.1807	1.1823	75
80	1.1363	1.1463	1.1529	1.1578	1.1618	1.1650	1.1676	1.1700	1.1721	1.1739	1.1756	1.1771	80
85	1.1312	1.1412	1.1478	1.1527	1.1566	1.1598	1.1625	1.1649	1.1669	1.1688	1.1704	1.1720	85
90	1.1260	1.1360	1.1426	1.1476	1.1515	1.1547	1.1574	1.1597	1.1618	1.1636	1.1653	1.1668	90
95	1.1209	1.1309	1.1375	1.1424	1.1463	1.1495	1.1522	1.1546	1.1566	1.1585	1.1602	1.1617	95
100	1.1158	1.1258	1.1323	1.1373	1.1412	1.1444	1.1471	1.1495	1.1515	1.1534	1.1550	1.1566	100
105	1.1106	1.1206	1.1272	1.1322	1.1361	1.1393	1.1420	1.1443	1.1464	1.1482	1.1499	1.1516	105
110	1.1055	1.1155	1.1221	1.1270	1.1309	1.1341	1.1368	1.1392	1.1412	1.1431	1.1447	1.1463	110
115	1.1004	1.1103	1.1169	1.1219	1.1258	1.1290	1.1248	1.1341	1.1361	1.1380	1.1396	1.1412	115
120	1.0952	1.1052	1.1118	1.1167	1.1207	1.1239	1.1265	1.1289	1.1310	1.1328	1.1345	1.1360	120
125	1.0901	1.1001	1.1067	1.1116	1.1155	1.1187	1.1214	1.1238	1.1258	1.1277	1.1293	1.1309	125
130	1.0849	1.0949	1.1015	1.1065	1.1104	1.1136	1.1163	1.1186	1.1207	1.1225	1.1242	1.1257	130
135	1.0798	1.0898	1.0964	1.1013	1.1052	1.1084	1.1111	1.1135	1.1155	1.1174	1.1190	1.1206	135
140	1.0746	1.0846	1.0912	1.0962	1.1001	1.1033	1.1060	1.1083	1.1104	1.1123	1.1139	1.1154	140
145	1.0695	1.0795	1.0861	1.0910	1.0950	1 0981	1.1008	1.1032	1.1053	1.1071	1.1088	1.1103	145
150	1.0643	1.0743	1.0809	1.0859	1.0898	1.0930	1.0957	1.0981	1.1001	1.1020	1.1036	1.1052	150
155	1.0592	1.0692	1.0758	1.0807	1.0846	1.0878	1.0905	1.0929	1.0950	1.0968	1.0985	1.1000	155
160	1.0540	1.0640	1.0706	1.0756	1.0795	1.0827	1.0854	1.0877	1.0898	1.0917	1.0933	1.0948	160
165	1.0489	1.0589	1.0655	1.0704	1.0743	1.0775	1.0802	1.0826	1.0846	1.0865	1.0881	1.0897	165
170	1.0437	1.0537	1.0603	1.0653	1.0692	1.0724	1.0751	1.0774	1.0795	1.0813	1.0830	1.0845	170
171	1.0427	1.0527	1.0593	1.0642	1.0681	1.0713	1.0740	1.0764	1.0785	1.0803	1.0820	1.0835	171
172	1.0417	1.0517	1.0583	1.0632	1.0671	1.0703	1.0730	1.0754	1.0774	1.0793	1.0809	1.0825	172
173	1.0406	1.0506	1.0572	1.0622	1.0661	1.0693	1.0720	1.0743	1.0764	1.0782	1.0799	1.0814	173
174	1.0396	1.0496	1.0562	1.0611	1.0651	1.0683	1.0709	1.0733	1.0754	1.0772	1.0789	1.0804	174
175	1.0386	1.0486	1.0552	1.0601	1.0640	1.0672	1.0699	1.0723	1.0743	1.0762	1.0778	1.0793	175
176	1.0375	1.0475	1.0541	1.0591	1.0630	1.0662	1.0689	1.0712	1.0733	1.0752	1.0768	1.0783	176
177	1.0365	1.0465	1.0531	1.0580	1.0620	1.0651	1.0678	1.0702	1.0723	1.0741	1.0758	1.0773	177
178	1.0355	1.0455	1.0521	1.0570	1.0609	1.0641	1.0668	1.0692	1.0712	1.0731	1.0747	1.0763	178
179	1.0344	1.0444	1.0510	1.0560	1.0599	1.0631	1.0658	1.0681	1.0702	1.0721	1.0737	1.0752	179
180	1.0334	1.0434	1.0500	1.0549	1.0589	1.0621	1.0647	1.0671	1.0692	1.0710	1.0727	1.0742	180
181	1.0324	1.0424	1.0490	1.0539	1.0578	1.0610	1.0637	1.0661	1.0681	1.0700	1.0716	1.0732	181
182	1.0313	1.0413	1.0479	1.0529	1.0568	1.0600	1.0627	1.0650	1.0671	1.0690	1.0706	1.0721	182
183	1.0303	1.0403	1.0469	1.0518	1.0558	1.0590	1.0616	1.0640	1.0661	1.0679	1.0696	1.0711	183
184	1.0293	1.0393	1.0459	1.0508	1.0547	1.0579	1.0606	1.0630	1.0650	1.0669	1.0685	1.0701	184
185	1.0282	1.0382	1.0448	1.0498	1.0537	1.0569	1.0596	1.0619	1.0640	1.0659	1.0675	1.0691	185
186	1.0272	1.0372	1.0438	1.0488	1.0527	1.0559	1.0585	1.0609	1.0630	1.0648	1.0665	1.0680	186
187	1.0262	1.0362	1.0428	1.0477	1.0516	1.0548	1.0575	1.0599	1.0619	1.0638	1.0654	1.0670	187
188	1.0251	1.0351	1.0417	1.0467	1.0506	1.0538	1.0565	1.0588	1.0609	1.0628	1.0644	1.0660	188
189	1.0241	1.0341	1.0407	1.0457	1.0496	1.0528	1.0554	1.0578	1.0599	1.0617	1.0634	1.0649	189
190	1.0231	1.0331	1.0397	1.0446	1.0485	1.0517	1.0544	1.0568	1.0588	1.0607	1.0623	1.0639	190
191	1.0220	1.0320	1.0386	1.0436	1.0475	1.0507	1.0534	1.0557	1.0578	1.0597	1.0613	1.0629	191
192	1.0210	1.0310	1.0376	1.0425	1.0465	1.0497	1.0523	1.0547	1.0568	1.0586	1.0603	1.0618	192
193	1.0200	1.0300	1.0366	1.0415	1.0454	1.0486	1.0513	1.0537	1.0557	1.0576	1.0592	1.0608	193
194	1.0189	1.0289	1.0355	1.0405	1.0444	1.0476	1.0503	1.0526	1.0547	1.0566	1.0582	1.0597	194
195	1.0179	1.0279	1.0345	1.0394	1.0434	1.0466	1.0492	1.0516	1.0537	1.0555	1.0572	1.0587	195
196	1.0169	1.0269	1.0335	1.0384	1.0423	1.0455	1.0482	1.0506	1.0526	1.0545	1.0561	1.0577	196
197	1.0158	1.0258	1.0324	1.0374	1.0413	1.0445	1.0472	1.0495	1.0516	1.0535	1.0551	1.0566	197
198	1.0148	1.0248	1.0314	1.0363	1.0403	1.0435	1.0461	1.0485	1.0506	1.0524	1.0541	1.0556	198
199	1.0138	1.0238	1.0304	1.0353	1.0392	1.0424	1.0451	1.0475	1.0495	1.0514	1.0530	1.0546	199
200	1.0127	1.0227	1.0293	1.0343	1.0382	1.0414	1.0441	1.0464	1.0485	1.0504	1.0520	1.0535	200
201	1.0117	1.0217	1.0283	1.0332	1.0372	1.0404	1.0430	1.0454	1.0475	1.0493	1.0510	1.0525	201
202	1.0107	1.0207	1.0273	1.0322	1.0361	1.0393	1.0420	1.0444	1.0464	1.0483	1.0499	1.0515	202
203	1.0096	1.0196	1.0262	1.0312	1.0351	1.0383	1.0410	1.0433	1.0454	1.0472	1.0489	1.0504	203
204	1.0086	1.0186	1.0252	1.0301	1.0340	1.0372	1.0399	1.0423	1.0444	1.0462	1.0479	1.0494	204
205	1.0076	1.0176	1.0242	1.0291	1.0330	1.0362	1.0389	1.0413	1.0433	1.0452	1.0468	1.0484	205
206	1.0065	1.0165	1.0231	1.0281	1.0320	1.0352	1.0379	1.0402	1.0423	1.0441	1.0458	1.0473	206
207	1.0055	1.0155	1.0221	1.0270	1.0309	1.0341	1.0368	1.0392	1.0413	1.0431	1.0448	1.0463	207
208	1.0045	1.0144	1.0210	1.0260	1.0299	1.0331	1.0358	1.0381	1.0402	1.0421	1.0437	1.0453	208
209	1.0034	1.0134	1.0200	1.0250	1.0289	1.0321	1.0347	1.0371	1.0392	1.0410	1.0427	1.0442	209
210	1.0024	1.0124	1.0190	1.0239	1.0278	1.0310	1.0337	1.0361	1.0381	1.0400	1.0416	1.0432	210
212	1.0003	1.0103	1.0169	1.0218	1.0258	1.0290	1.0316	1.0340	1.0361	1.0379	1.0396	1.0411	212
215	0.9972	1.0072	1.0138	1.0188	1.0227	1.0259	1.0285	1.0309	1.0330	1.0348	1.0365	1.0380	215
220	0.9920	1.0020	1.0086	1.0135	1.0174	1.0206	1.0233	1.0257	1.0277	1.0296	1.0312	1.0328	220
225	0.9868	0.9968	1.0034	1.0083	1.0123	1.0155	1.0181	1.0205	1.0226	1.0244	1.0261	1.0276	225
230	0.9816	0.9916	0.9981	1.0031	1.0070	1.0102	1.0129	1.0153	1.0173	1.0192	1.0208	1.0224	230
235	0.9764	0.9864	0.9930	0.9979	1.0019	1.0050	1.0077	1.0101	1.0122	1.0140	1.0157	1.0172	235
240	0.9711	0.9811	0.9877	0.9927	0.9966	0.9998	1.0025	1.0048	1.0069	1.0088	1.0104	1.0120	240
245	0.9660	0.9759	0.9825	0.9874	0.9913	0.9945	0.9972	0.9996	1.0016	1.0035	1.0052	1.0067	245
250	0.9606	0.9706	0.9772	0.9822	0.9861	0.9893	0.9920	0.9943	0.9964	0.9982	0.9999	1.0014	250
255	0.9555	0.9655	0.9721	0.9770	0.9809	0.9841	0.9868	0.9892	0.9912	0.9931	0.9947	0.9963	255
260	0.9502	0.9602	0.9668	0.9718	0.9757	0.9789	0.9816	0.9839	0.9860	0.9878	0.9895	0.9910	260
265	0.9450	0.9550	0.9616	0.9665	0.9704	0.9736	0.9763	0.9787	0.9807	0.9826	0.9842	0.9858	265
270	0.9397	0.9497	0.9563	0.9613	0.9652	0.9684	0.9710	0.9734	0.9755	0.9773	0.9790	0.9805	270
275	0.9345	0.9446	0.9511	0.9560	0.9599	0.9631	0.9658	0.9682	0.9702	0.9721	0.9737	0.9754	275
280	0.9292	0.9392	0.9458	0.9507	0.9547	0.9579	0.9605	0.9629	0.9650	0.9668	0.9685	0.9700	280
285	0.9238	0.9338	0.9404	0.9454	0.9493	0.9525	0.9552	0.9575	0.9596	0.9615	0.9631	0.9647	285
290	0.9186	0.9286	0.9352	0.9401	0.9440	0.9472	0.9499	0.9523	0.9543	0.9562	0.9579	0.9594	290
295	0.9133	0.9233	0.9299	0.9349	0.9388	0.9420	0.9447	0 9470	0.9491	0.9509	0.9526	0.9541	295
300	0.9080	0.9180	0.9246	0.9295	0.9334	0.9366	0.9393	0.9417	0.9437	0.9456	0.9472	0.9488	300

Equivalent Evaporation From and at 212 Degrees--Continued

Temperature of Feed Water Degrees Fahrenheit	Pressure of Steam in Pounds Absolute—Dry Saturated												Temperature of Feed Water Degrees Fahrenheit
	135	145	155	165	175	185	195	205	215	225	235	245	
32	1.2279	1.2292	1.2304	1.2315	1.2324	1.2333	1.2342	1.2351	1.2357	1.2365	1.2372	1.2378	32
35	1.2248	1.2261	1.2273	1.2283	1.2293	1.2302	1.2311	1.2319	1.2326	1.2334	1.2341	1.2347	35
40	1.2197	1.2209	1.2221	1.2232	1.2241	1.2250	1.2259	1.2268	1.2274	1.2282	1.2289	1.2295	40
45	1.2145	1.2157	1.2170	1.2180	1.2189	1.2198	1.2208	1.2216	1.2222	1.2230	1.2238	1.2244	45
50	1.2093	1.2106	1.2118	1.2128	1.2137	1.2147	1.2156	1.2164	1.2170	1.2179	1.2186	1.2192	50
55	1.2042	1.2054	1.2066	1.2077	1.2086	1.2095	1.2104	1.2113	1.2119	1.2127	1.2134	1.2141	55
60	1.1990	1.2002	1.2015	1.2025	1.2034	1.2044	1.2053	1.2061	1.2067	1.2076	1.2083	1.2089	60
65	1.1939	1.1951	1.1963	1.1974	1.1983	1.1992	1.2002	1.2010	1.2016	1.2024	1.2031	1.2038	65
70	1.1887	1.1900	1.1912	1.1922	1.1932	1.1941	1.1950	1.1958	1.1965	1.1973	1.1980	1.1986	70
75	1.1836	1.1848	1.1861	1.1871	1.1880	1.1889	1.1899	1.1907	1.1913	1.1921	1.1929	1.1935	75
80	1.1785	1.1797	1.1809	1.1820	1.1829	1.1838	1.1847	1.1856	1.1862	1.1870	1.1877	1.1883	80
85	1.1733	1.1745	1.1758	1.1768	1.1777	1.1787	1.1796	1.1804	1.1810	1.1819	1.1826	1.1832	85
90	1.1682	1.1694	1.1707	1.1717	1.1726	1.1735	1.1745	1.1753	1.1759	1.1767	1.1775	1.1781	90
95	1.1630	1.1643	1.1655	1.1665	1.1675	1.1684	1.1693	1.1701	1.1708	1.1716	1.1723	1.1729	95
100	1.1579	1.1591	1.1604	1.1614	1.1623	1.1633	1.1642	1.1650	1.1657	1.1665	1.1672	1.1678	100
105	1.1528	1.1540	1.1552	1.1563	1.1572	1.1581	1.1591	1.1599	1.1606	1.1613	1.1620	1.1627	105
110	1.1476	1.1489	1.1501	1.1511	1.1521	1.1530	1.1539	1.1547	1.1553	1.1562	1.1569	1.1575	110
115	1.1425	1.1437	1.1450	1.1460	1.1469	1.1479	1.1488	1.1496	1.1503	1.1511	1.1518	1.1524	115
120	1.1374	1.1386	1.1398	1.1409	1.1418	1.1427	1.1436	1.1445	1.1452	1.1459	1.1466	1.1472	120
125	1.1322	1.1335	1.1347	1.1357	1.1366	1.1376	1.1385	1.1393	1.1400	1.1408	1.1415	1.1421	125
130	1.1271	1.1283	1.1295	1.1306	1.1315	1.1324	1.1334	1.1342	1.1349	1.1356	1.1363	1.1370	130
135	1.1219	1.1232	1.1244	1.1254	1.1264	1.1273	1.1282	1.1290	1.1298	1.1305	1.1312	1.1318	135
140	1.1168	1.1180	1.1193	1.1203	1.1212	1.1221	1.1231	1.1239	1.1246	1.1253	1.1261	1.1267	140
145	1.1116	1.1129	1.1141	1.1151	1.1161	1.1170	1.1179	1.1188	1.1195	1.1202	1.1209	1.1215	145
150	1.1065	1.1077	1.1090	1.1100	1.1109	1.1119	1.1128	1.1136	1.1143	1.1150	1.1158	1.1164	150
155	1.1013	1.1026	1.1038	1.1048	1.1058	1.1067	1.1076	1.1085	1.1092	1.1099	1.1106	1.1112	155
160	1.0962	1.0974	1.0987	1.0997	1.1006	1.1015	1.1025	1.1033	1.1040	1.1047	1.1055	1.1061	160
165	1.0910	1.0923	1.0935	1.0945	1.0955	1.0964	1.0973	1.0981	1.0989	1.0996	1.1003	1.1009	165
170	1.0859	1.0871	1.0883	1.0894	1.0903	1.0912	1.0922	1.0930	1.0937	1.0944	1.0951	1.0958	170
171	1.0848	1.0861	1.0873	1.0883	1.0893	1.0902	1.0911	1.0920	1.0927	1.0934	1.0941	1.0947	171
172	1.0838	1.0850	1.0863	1.0873	1.0882	1.0892	1.0901	1.0909	1.0916	1.0924	1.0931	1.0937	172
173	1.0828	1.0840	1.0853	1.0863	1.0872	1.0881	1.0891	1.0899	1.0906	1.0913	1.0921	1.0927	173
174	1.0817	1.0830	1.0842	1.0853	1.0862	1.0871	1.0880	1.0889	1.0896	1.0903	1.0910	1.0916	174
175	1.0807	1.0820	1.0832	1.0842	1.0852	1.0861	1.0870	1.0878	1.0886	1.0893	1.0900	1.0906	175
176	1.0797	1.0809	1.0822	1.0832	1.0841	1.0850	1.0860	1.0868	1.0875	1.0882	1.0890	1.0896	176
177	1.0786	1.0799	1.0811	1.0822	1.0831	1.0840	1.0849	1.0858	1.0865	1.0872	1.0879	1.0885	177
178	1.0776	1.0789	1.0801	1.0811	1.0820	1.0830	1.0839	1.0847	1.0854	1.0862	1.0869	1.0875	178
179	1.0766	1.0778	1.0791	1.0801	1.0810	1.0819	1.0829	1.0837	1.0844	1.0851	1.0859	1.0865	179
180	1.0756	1.0768	1.0780	1.0791	1.0800	1.0809	1.0818	1.0827	1.0834	1.0841	1.0848	1.0854	180
181	1.0745	1.0758	1.0770	1.0780	1.0790	1.0799	1.0808	1.0816	1.0824	1.0831	1.0838	1.0844	181
182	1.0735	1.0747	1.0760	1.0770	1.0779	1.0788	1.0798	1.0806	1.0813	1.0820	1.0828	1.0834	182
183	1.0725	1.0737	1.0749	1.0760	1.0769	1.0778	1.0787	1.0796	1.0803	1.0810	1.0817	1.0823	183
184	1.0714	1.0727	1.0739	1.0749	1.0759	1.0768	1.0777	1.0785	1.0793	1.0800	1.0807	1.0813	184
185	1.0704	1.0716	1.0729	1.0739	1.0748	1.0758	1.0767	1.0775	1.0782	1.0789	1.0797	1.0803	185
186	1.0694	1.0706	1.0718	1.0729	1.0738	1.0747	1.0756	1.0765	1.0772	1.0779	1.0786	1.0793	186
187	1.0683	1.0696	1.0708	1.0718	1.0728	1.0737	1.0746	1.0754	1.0762	1.0769	1.0776	1.0782	187
188	1.0673	1.0685	1.0698	1.0708	1.0717	1.0727	1.0736	1.0744	1.0751	1.0758	1.0766	1.0772	188
189	1.0663	1.0675	1.0687	1.0698	1.0707	1.0716	1.0725	1.0734	1.0741	1.0748	1.0755	1.0762	189
190	1.0652	1.0665	1.0677	1.0687	1.0697	1.0706	1.0715	1.0723	1.0731	1.0738	1.0745	1.0751	190
191	1.0642	1.0654	1.0667	1.0677	1.0686	1.0695	1.0705	1.0713	1.0720	1.0727	1.0735	1.0741	191
192	1.0632	1.0644	1.0656	1.0667	1.0676	1.0685	1.0694	1.0703	1.0710	1.0717	1.0724	1.0731	192
193	1.0621	1.0634	1.0646	1.0656	1.0666	1.0675	1.0684	1.0692	1.0700	1.0707	1.0714	1.0720	193
194	1.0611	1.0623	1.0636	1.0646	1.0655	1.0664	1.0674	1.0682	1.0689	1.0696	1.0704	1.0710	194
195	1.0601	1.0613	1.0625	1.0636	1.0645	1.0654	1.0663	1.0672	1.0679	1.0686	1.0693	1.0700	195
196	1.0590	1.0603	1.0615	1.0625	1.0635	1.0644	1.0653	1.0661	1.0669	1.0676	1.0683	1.0689	196
197	1.0580	1.0592	1.0605	1.0615	1.0624	1.0633	1.0643	1.0651	1.0658	1.0665	1.0673	1.0679	197
198	1.0570	1.0582	1.0594	1.0605	1.0614	1.0623	1.0632	1.0641	1.0648	1.0655	1.0662	1.0668	198
199	1.0559	1.0572	1.0584	1.0594	1.0603	1.0613	1.0622	1.0630	1.0637	1.0645	1.0652	1.0658	199
200	1.0549	1.0561	1.0574	1.0584	1.0593	1.0602	1.0612	1.0620	1.0627	1.0634	1.0642	1.0648	200
201	1.0539	1.0551	1.0563	1.0574	1.0584	1.0592	1.0601	1.0610	1.0617	1.0624	1.0631	1.0637	201
202	1.0528	1.0541	1.0553	1.0563	1.0572	1.0582	1.0591	1.0599	1.0606	1.0614	1.0621	1.0627	202
203	1.0518	1.0530	1.0543	1.0553	1.0562	1.0571	1.0581	1.0589	1.0596	1.0603	1.0611	1.0617	203
204	1.0507	1.0520	1.0532	1.0542	1.0552	1.0561	1.0570	1.0579	1.0586	1.0593	1.0600	1.0606	204
205	1.0497	1.0509	1.0522	1.0532	1.0541	1.0551	1.0560	1.0568	1.0575	1.0583	1.0590	1.0596	205
206	1.0487	1.0499	1.0511	1.0522	1.0531	1.0540	1.0550	1.0558	1.0565	1.0572	1.0579	1.0586	206
207	1.0476	1.0489	1.0501	1.0511	1.0521	1.0530	1.0539	1.0548	1.0555	1.0562	1.0569	1.0575	207
208	1.0466	1.0478	1.0491	1.0501	1.0510	1.0520	1.0529	1.0537	1.0544	1.0552	1.0559	1.0565	208
209	1.0456	1.0468	1.0480	1.0491	1.0500	1.0509	1.0519	1.0527	1.0534	1.0541	1.0548	1.0555	209
210	1.0445	1.0458	1.0470	1.0480	1.0490	1.0499	1.0508	1.0516	1.0524	1.0531	1.0538	1.0544	210
212	1.0425	1.0437	1.0449	1.0460	1.0469	1.0478	1.0487	1.0496	1.0503	1.0510	1.0517	1.0523	212
215	1.0394	1.0406	1.0418	1.0429	1.0438	1.0447	1.0457	1.0465	1.0472	1.0479	1.0486	1.0493	215
220	1.0341	1.0353	1.0366	1.0376	1.0385	1.0395	1.0404	1.0412	1.0419	1.0427	1.0434	1.0440	220
225	1.0290	1.0302	1.0314	1.0325	1.0334	1.0343	1.0352	1.0361	1.0368	1.0375	1.0382	1.0388	225
230	1.0237	1.0249	1.0262	1.0272	1.0281	1.0291	1.0300	1.0308	1.0315	1.0323	1.0330	1.0336	230
235	1.0185	1.0198	1.0210	1.0221	1.0230	1.0239	1.0248	1.0257	1.0264	1.0271	1.0278	1.0284	235
240	1.0133	1.0145	1.0158	1.0168	1.0177	1.0187	1.0196	1.0204	1.0211	1.0218	1.0226	1.0232	240
245	1.0080	1.0093	1.0105	1.0115	1.0125	1.0134	1.0143	1.0151	1.0159	1.0166	1.0173	1.0179	245
250	1.0028	1.0040	1.0053	1.0063	1.0072	1.0081	1.0091	1.0099	1.0166	1.0113	1.0121	1.0127	250
255	0.9976	0.9989	1.0001	1.0011	1.0021	1.0030	1.0039	1.0047	1.0055	1.0062	1.0069	1.0075	255
260	0.9924	0.9936	0.9948	0.9959	0.9968	0.9977	0.9987	0.9995	1.0002	1.0009	1.0016	1.0023	260
265	0.9871	0.9884	0.9896	0.9906	0.9915	0.9925	0.9934	0.9942	0.9950	0.9957	0.9964	0.9970	265
270	0.9819	0.9831	0.9843	0.9854	0.9863	0.9872	0.9881	0.9890	0.9897	0.9904	0.9911	0.9918	270
275	0.9766	0.9778	0.9791	0.9801	0.9810	0.9820	0.9829	0.9837	0.9844	0.9852	0.9859	0.9865	275
280	0.9714	0.9726	0.9738	0.9749	0.9758	0.9767	0.9776	0.9785	0.9792	0.9799	0.9806	0.9812	280
285	0.9660	0.9672	0.9685	0.9695	0.9704	0.9714	0.9723	0.9731	0.9738	0.9745	0.9753	0.9759	285
290	0.9607	0.9620	0.9632	0.9642	0.9652	0.9661	0.9670	0.9678	0.9686	0.9693	0.9700	0.9706	290
295	0.9555	0.9567	0.9580	0.9590	0.9599	0.9608	0.9618	0.9626	0.9633	0.9640	0.9648	0.9654	295
300	0.9501	0.9514	0.9526	0.9536	0.9546	0.9555	0.9564	0.9572	0.9580	0.9587	0.9594	0.9600	300

nearly five and one-half times as much heat would be required to boil it away. If the flask absorbed heat at the same rate all the time it would take over five times as long to make the water into steam after it began to boil as to heat it to the boiling point. This evaporation is taking place "from and at 212 deg.," i.e., from feed water of 212 deg. temperature into steam of 212 deg. temperature and 14.7 lb. pressure, and this evaporation from and at 212 deg. requiring 970.4 B.t.u. per lb. is the standard to which evaporations from other temperatures of feed and at other pressure are referred for comparison.

We have seen above that it takes 1027.88 B.t.u. to make a pound of steam under the conditions of the supposed test. Then each pound of steam made under these conditions takes

$$1027.88 \div 970.4 = 1.0592$$

times as much heat as it does to make a pound of steam "from and at 212 deg." This figure 1.0592 is called the "factor of evaporation" for the given condition. Tables of them are to be found in most engineers' reference books. The accompanying table is reproduced from POWER of May 10, 1910, at which time it was calculated for the then new values of the Marks-Davis tables. The factors are found by dividing the difference between the total heat H of the steam at the given pressure and the heat of the liquid h at the feed-water temperature, by 970.4.

$$\textit{factor of evaporation} = \frac{H - h}{970.4}$$

We have found above that the boiler under test evaporated 13,282.453 lb. of water per hour from 196 deg. and at 122.6 lb. This would be equivalent to

$$13{,}282.453 \times 1.0592 = 14{,}068.774 \textit{ lb.}$$

from and at 212 deg.

The evaporation of 34.5 lb. per hour from and at 212 deg. is the requirement per boiler horsepower. The horsepower developed by the boiler on test was therefore

$$\frac{14{,}068.774}{34.5} = 407.79 \textit{ boiler horsepower}$$

This boiler horsepower corresponds to the absorption of 33,478.8 B.t.u. per hour. The horsepower could be found then by multiplying the evaporation in pounds per hour by the British thermal units required per pound evaporated, and dividing the number of British thermal units absorbed per hour thus found by 33,478.8 thus:

$$\frac{13{,}282.45\tfrac{1}{2} \times 1027.88}{33{,}478.8} = 407.8 \textit{ boiler horsepower}$$

The fundamental basis for the horsepower is that adopted by the Committee on Boiler Tests of the Centennial Exposition of 1876, 30 lb. from 100 deg. into steam of 70-lb. gage which requires 1115.33 B.t.u. per lb.; and the evaporation of 30 lb. under these conditions requires

$$1115.33 \times 30 = 33{,}459.9$$

or dropping the fraction 33,460 B.t.u. per hour, which corresponds to

$$\frac{33{,}459.9}{970.4} = 34.48 \textit{ lb.}$$

from and at 212 deg. The Committee of Boiler Tests of the American Society of Mechanical Engineers recommended that this shall be considered equal to 34.5 lb. from and at 212.

To determine the percentage of the rated capacity divide the horsepower as determined by the test by the rated horsepower and multiply by 100. Thus if the boiler in the above test were rated at 350 hp. it would have been running at

$$\frac{407.79 \times 100}{350} = 116.51 \textit{ per cent.}$$

of its rated capacity or 16.51 per cent. above its rating.

If it were rated at 500 hp. it would have been running at

$$\frac{407.79 \times 100}{500} = 81.56 \textit{ per cent.}$$

of its rated capacity, or

$$100 - 81.56 = 18.44 \textit{ per cent.}$$

below its rating.

With Superheated Steam

If the steam were superheated instead of moist it would be necessary only to use the value for the total heat of the superheated steam (which may be found in the Marks-Davis table for superheated steam) in the same process as above, except, of course, that there is no correction for quality. Suppose, for example, the conditions and results were the same as before, except that the steam instead of having the quality 96.5 per cent., i.e., carrying 3.5 per cent. moisture, were superheated 100 deg.

The table shows that to make a pound of steam of 137 lb. pressure, superheated 100 deg. from feed water of 32 would take 1247.4 B.t.u. The feed water at 196 deg. has already in it 163.92 B.t.u. above 32. The heat required per pound is therefore

$$1247.4 - 163.92 = 1083.48 \textit{ B.t.u.}$$

In this case all the water fed to the boilers

$$137{,}642 \div 10 = 13{,}764.2 \textit{ lb. per hour}$$

was evaporated. The boiler, therefore, absorbed

$$13{,}764.2 \times 1083.48 = 14{,}913{,}235.416 \textit{ B.t.u. per hour}$$

which is equivalent to

$$\frac{14{,}913{,}235.416}{33{,}460} = 445.7 \textit{ boiler horsepower}$$

Correcting for Leakage

Suppose that during the test the boiler or some of its connections below the water line, as the blowoff valve or pipe, commence to leak. It does not make any difference if the leak is where it will blow steam. If the boiler has made the steam, that is all we want. We do not care, so far as the purpose of the test is concerned, whether the steam blows out of the safety valve, or out of a leaky joint or goes to a condenser directly or through an engine. But if some of the water, which has been credited to the boiler is got rid of by leakage instead of by evaporation, less heat has been absorbed and a correction must be made for it.

To make this correction the amount of leakage and the average temperature of the leaking water should be known. If the temperature is above 212, some of the water will turn into steam as soon as it gets outside the boiler and it may be necessary to measure the quantity by measuring the drop of the water line in a given time,

when no steam is being taken from the boiler and the pressure is constant at that of the test, or the rate of feed necessary to keep up with the leak. It may be hard to determine the temperature of the escaping water, which may not be that due to the pressure of the steam. But this article is upon working up a boiler test, not upon making one. Assuming a test with results as given above, 100 deg. superheat, 880 lb. leakage; temperature of leaking water, 340 deg.; what is the horsepower?

We must subtract from the water credited to the boiler this 880 lb. which it did not evaporate.

$$137{,}642 - 880 = 136{,}762 \ lb.$$

evaporated in 10 hr., or 13,676.2 lb., per hr. We found above that it required 1083.48 B.t.u. per pound so that the water evaporated represents.

$$13{,}676.2 \times 1083.48 = 14{,}817{,}889.176 \ B.t.u.$$

But in addition the boiler absorbed the heat, which was used to heat the water which leaked

1 lb. at 340 deg. carries 311.00 B.t.u. above 32
1 lb. at 196 deg. carries 163.92 B.t.u. above 32

147.08 B.t.u. added

The 88 lb. leaked per hour would then have taken out of the boiler more than they brought in

$$147.08 \times 88 = 12{,}943.04 \ B.t.u.$$

The boiler has absorbed the heat and when the leak is stopped it will be useful for making steam. If we want to know the capacity of the boiler when it is not leaking we must credit it with this heat

14,817,889.176 B.t.u. used in evaporation
12,943.04 B.t.u. lost by leaking

33,478.8) 14,804,946.136 B.t.u. absorbed per hour
442.2 boiler hp.

In the case of the boiler making moist steam, some of the heat which is absorbed by the boiler goes off in the entrained water which is heated from the feed to the steam temperature. If the steam is to be used for driving a turbine or engine this moisture is worse than useless and the boiler should get no credit for the heat which it carries off. If the steam is used for heating or processes this heat may be as useful as any other, and will be credited to the boiler or not, according to what you are trying to determine by the test.

When we come to making up a heat balance and finding out what has become of all the heat in the fuel this item will have to be reckoned with, but that is another story.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Some interesting boiler installations are found. Many of the boiler furnaces were equipped with in-swinging fire-doors which are a safeguard to the firemen. The appearance of one engine room is a surprise, because of its neatness and general layout; the engineer relates the "story of his life."

Traveling about the mines with Hunter, together with the visits made alone, had given me a pretty good insight regarding the mechanical end of mining coal. I found that at anthracite-mine boiler plants hand firing was used altogether, as buckwheat coal was burned. A general practice is to have wooden coal bunkers built the length of the boiler house in front of the boilers with openings at the bottom, through which the coal comes out onto the boiler-room floor handy for the fireman. This is shown in Fig. 1.

On many of the boiler furnaces weighted, tilting doors are used, which are a safeguard to some extent against injury from bursting tubes, because if one does fail the pressure in the furnace tends to shut the doors tighter, and they cannot blow open. Of course, if a tube bursts

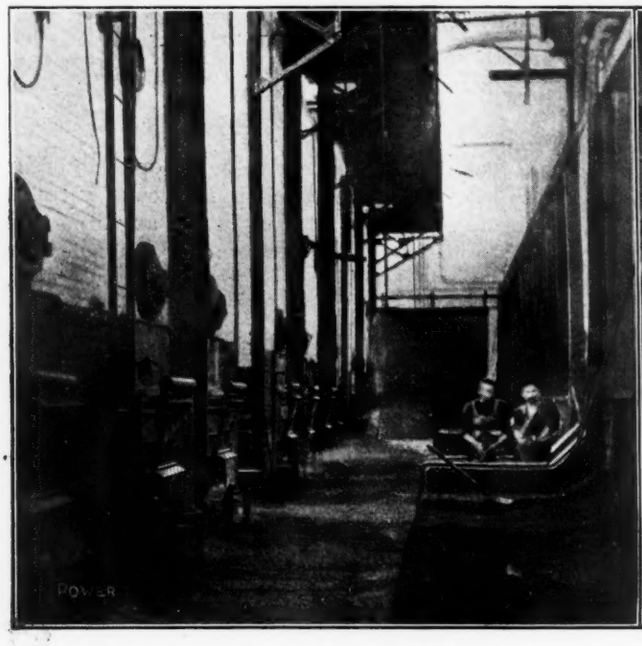


Fig. 1. Boiler Room and Wooden Coal Bunkers

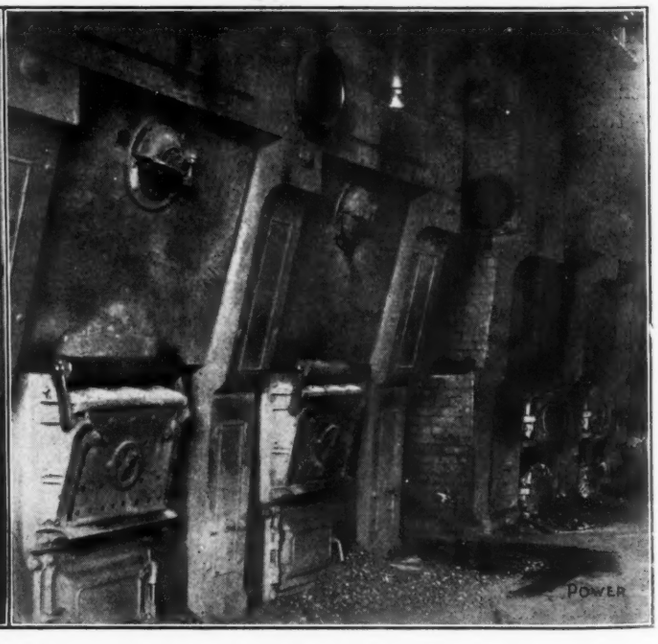


Fig. 2. Two Kinds of Furnace Doors

while the fireman is working on the fires, he is almost sure to be severely burned or killed. The value of these doors is indicated by the comparison of two kinds of furnace doors, shown in Fig. 2. There is nothing to prevent the doors shown on the second boiler front from blowing open in case a tube should burst.

The boilers shown in Fig. 3 are of the locomotive type, each of 350-hp. capacity, carrying a steam pressure of 115 lb. The furnaces are fitted with shaking grates and buckwheat coal is used. It is claimed by those in charge that they give very good results, but from the color of the iron smoke-stack it would appear that the gases escaping to the atmosphere were at a very high temperature. As in other boiler plants using anthracite coal, the supply was kept in a wooden bunker built in front of the boilers. In another boiler plant at a soft-coal mine I found stokers in use, Fig. 4, the fuel feeding from an overhead bunker, the coal supply of which was maintained by a belt conveyor. Coal fresh from the mine was dumped into the crushing rolls before reaching the conveyor.

In Fig. 5 is shown a view behind a set of water-tube boilers. This boiler plant was kept exceptionally clean, as indicated. A trough was made in the cement flooring along the length of boilers to take care of waste water, and the blowoff pipes from each boiler were placed in a trough which ran at right angles to the first. These troughs carried away any leakage water and permitted of washing down the floor with dispatch.

The clothes a man wears do not indicate the kind of a man inside of them. Neither does the housing of a power plant designate the kind of machinery likely to be found inside. In one instance the power house was built of wood, painted red. There was no outside indication that

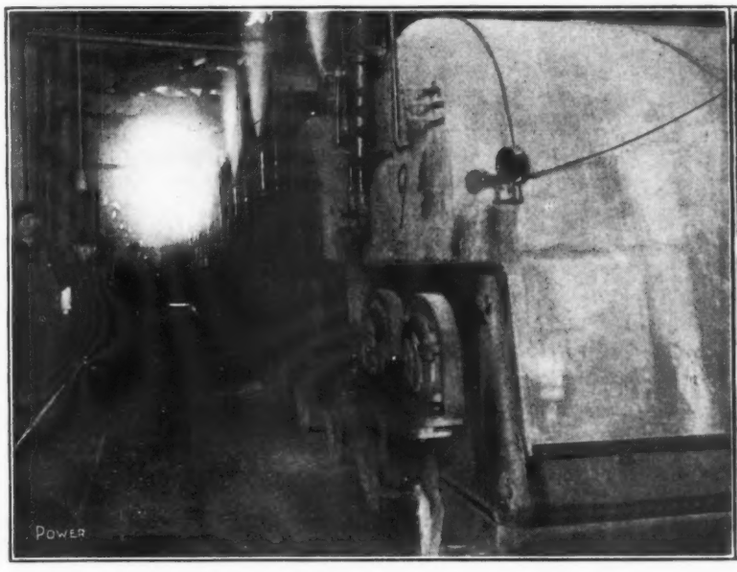


FIG. 3. BATTERY OF LOCOMOTIVE-TYPE BOILERS

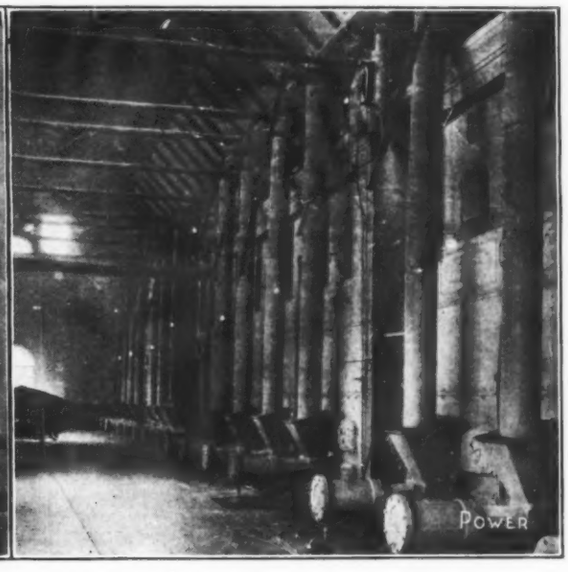


FIG. 4. WATER-TUBE BOILERS AND MECHANICAL STOKERS

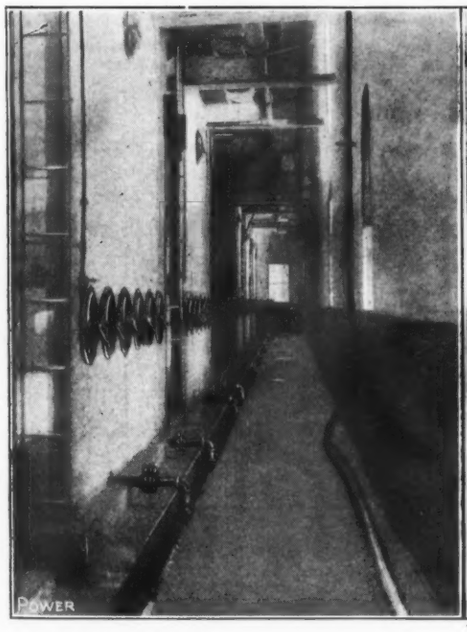


FIG. 5. REAR OF A BATTERY OF BOILERS

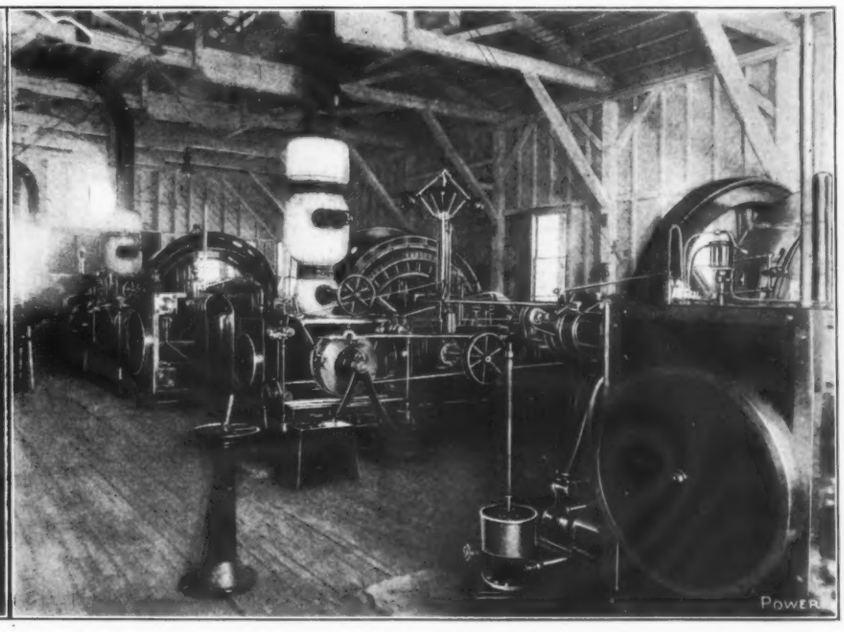


FIG. 6. CORLISS ENGINES AT A COLLIERY

anything but the general run of dirty, noisy machinery would be found inside. It was, therefore, somewhat of a surprise to find a well laid-out plant containing two 16 and 26 by 42-in. and one 22 and 38 by 42-in. cross-compound, noncondensing Corliss engines, each directly connected to alternating-current generators. Then there was a motor-driven exciter unit, also a steam-driven exciter. The boiler plant contained six 250-hp. water-tube boilers, carrying 160 lb. pressure. Fig. 6 is a view of the engine room.

All of the machines were painted maroon color and were kept clean and bright by frequent wiping. The flooring, although of boards, was washed clean, showing that the engineer in charge had pride in the appearance of the plant.

After getting acquainted with the engineer and his assistant, I began asking personal questions. Bringing out a couple of ever-ready cigars and getting them properly burning, I asked Mr. Engineer how he happened to get into the game.

"It's the same in my case as in that of others," said he. "I began working about a mine long before I should have left school. My first job was as trapper boy, tending entry doors. When it came time to go home at night, I used to stop in at the pump rooms which were near the foot of the shaft, and watch the men."

"That showed you had the engineering germ. Most boys would have hustled to the surface to play ball or go fishing."

"Yes, I suppose so. As a result I finally got a chance to care for a small pump located in a narrow, dark, dirty hole, but for all that it was the greatest day of my life when I was first left alone with that pump. I felt as if the entire mine operation rested upon my shoulders.

"This advance opened my eyes and I saw that if I did not know more than I did at that time I would finish as a pump runner. I had often looked with longing eyes at the engines in the above-ground plant, but the engineer never allowed us boys inside. Finally a new man came on the job and I suppose my frequent visits to the engine-room door showed that I was considerably interested, and on one occasion he asked me to come in. Gee, that was a treat. The engineer answered my thousand and one questions readily and quite a friendship sprang up between us."

"It wasn't long before I determined to become a stationary engineer and I began to study nights, pick up a little information here and a little there. Finally I got in with my engineer friend as assistant engineer, after serving a time as a fireman, and, some years later, when my chief left to go to a better job, his place was offered to me, which I did not refuse, you may rest assured. But if it had not been for the instruction my chief had given while with him the job would have been beyond me. I was in that plant until this one was built, when I came here, as you see. That's about all there is to it; lots of hard work, knocks and a determination to be something besides a miner's helper."

It was dark before I left the plant, and as I carefully picked my way over the rough ground toward the village, I realized more than ever that it is not luck that places a man in a position, but that it is the determination to make something of himself that helps him to win out in the struggle.

Flow of Steam in Pipes

In the *Wisconsin Engineer* for November, Prof. D. E. Foster gave an interesting chart for determining the size of steam pipes. The chart, which was based on a formula by A. E. Berggren, is reproduced herewith.

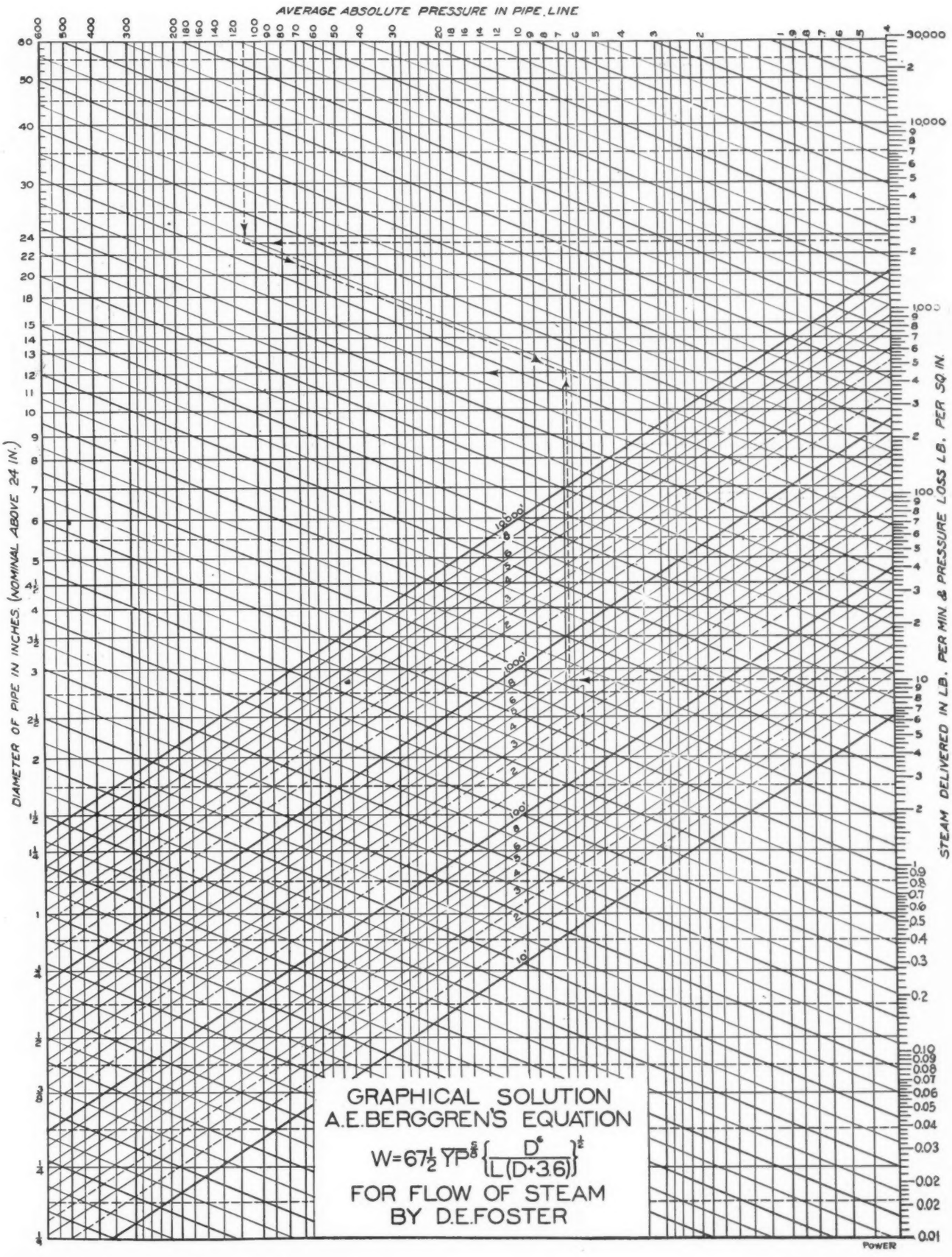
As a general rule, the engineer has a machine demanding a certain quantity of steam, located at a given distance from the source of supply, the initial pressure of which is a fixed quantity, and he wishes to allow a certain drop of pressure between the source and the machine. This drop is generally between ½ and 4 lb. per 100 ft. of pipe. With these data at hand, he must determine the size of the required pipe. Suppose that 2300 lb. of steam are required at a machine 500 ft. away from a boiler under a pressure of 115 lb. abs., and that the total drop is to be 10 lb., or 2 lb. per 100 ft. The average pressure in the pipe line then will be 110 lb.

Referring to the chart, the intersection of a horizontal representing 2300 lb. of steam with a vertical representing 110 lb. average pressure in the pipe line will determine a diagonal. The intersection of this diagonal with a second vertical, determined by the intersection of a second horizontal representing 10 lb. total loss of pressure, and a second diagonal representing 500 ft. of pipe line, will determine a third horizontal giving 12 in. as the proper size of pipe. The solution of this problem has been indicated on the chart by dotted lines and arrows.

The chart may be used to determine quantity when the other four factors are known or assumed. Suppose that the demand in the problem given above be increased in the future to 3200 lb. by the installation of a larger machine. If the initial pressure remains the same, the drop in pressure will have to be increased. In this case the drop must be estimated. If it be assumed to be 18 lb., the average pipe-line pressure will be 9 lb. less than the boiler pressure, or 106 lb. Following through the chart as before, the probable loss will be 17 lb. This value is so close to the assumed value that it will be unnecessary to check it.

As another example, assume that the demand be increased to 5000 lb. per min., that the pressure at the machine be increased to 140 lb., and that the initial pressure necessary to deliver this quantity is desired. It will be seen that the drop in this case is also unknown; hence the probable loss will have to be estimated. Assuming that it will be 20 lb., the average pipe-line pressure will be 150 lb. Using these data, the corresponding loss is 25 to 26 lb., which indicates that the initial pressure should be about 165 lb. Taking an average pipe-line pressure of 152.5 lb., a further check shows that this figure is about right.

In the first problem the solution gave 12 in. exactly. Generally speaking, however, the solution of such a problem will give a size other than standard, in which case either the size above is selected, and the pressure loss is decreased, or the size below and this loss increased.


AVERAGE ABSOLUTE PRESSURE IN PIPE LINE
DIAMETER OF PIPE IN INCHES. (NOMINAL ABOVE 24 IN.)
STEAM DELIVERED IN LB. PER MIN. & PRESSURE LOSS LB. PER SQ. IN.
GRAPHICAL SOLUTION
A.E. BERGGREN'S EQUATION
$W = 67\frac{1}{2}\sqrt{Y}P^{\frac{8}{9}}\left\{\frac{D^5}{L(D+3.6)}\right\}^{\frac{1}{2}}$
FOR FLOW OF STEAM
BY D.E. FOSTER
POWER

Grounding Methods and Devices

By John A. Randolph

SYNOPSIS—The necessity for grounding, methods commonly employed and the precautions to be observed.

The subject of grounding is simple from the construction standpoint, but it nevertheless requires careful attention and foresight if the best results are to be obtained. In general, there are two purposes for which grounding is employed, namely, to provide an indispensable part of the working circuit, as in the lightning arrester, the ground detector and various ground return systems; and for protection, as in the case of all grounded cable sheathings, pipes, frameworks, three-wire neutrals and transformer secondaries. It is important that the grounding connections and circuits provided for both of these general functions be in good working order at all times. However, on purely protective systems, it is possible for faults to pass unnoticed indefinitely unless the system is given careful attention. The existence of a fault on such a system may result in serious accident by preventing the operation of the system. There is always the possibility of a breakdown in the insulation of a wire or cable which may cause the sheathing, piping or other adjacent metallic parts to become alive. With these parts well grounded, there is little danger of accident, as the ground connection will form a short-circuit which will either operate the fuses or automatic cutouts on the faulty circuit or by providing a continuous path of low resistance to the escaping current, will afford a safeguard to life and property which would otherwise be endangered by contact with the live parts.

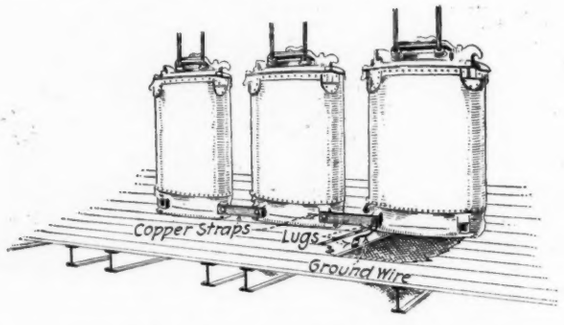
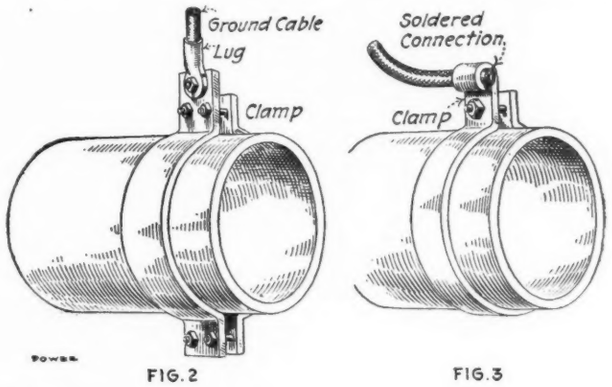


Fig. 1. Showing Method of Grounding Transformer Cases

These protective measures should be carried out not only on the conductors themselves and their adjacent metallic parts, but on all metailic sheathings, piping, framework, casings and details which may form a part of the structure or apparatus used in the control and distribution of high-voltage currents and which are so located that they could possibly become alive through the breakdown of insulation on the working circuit. This includes all oil-switch steelwork, current-transformer supports and the casings of potential transformers. Moreover, where step-up or step-down transformers are used, their casings and supporting steelwork, if any, together with any cable supports of steel, should be grounded unless already rendered safe by insulation. A convenient means of grounding transformer casings is shown in Fig. 1. This injunction also applies to generators, motors, rotary converters and other machinery which may be carrying dangerous voltages.

Methods of Grounding

There are three fundamental requisites to consider in providing a ground: First, it should be permanent and stable; second, it should have low resistance, and, third, it should be of such a nature as not to suffer readily from deterioration. No ground should be used which is likely



Two Ways of Securing Ground Wire to Pipe

to be disturbed for any reason. Furthermore, grounds should be avoided which will offer appreciable resistance to any currents which are likely to flow through them. For this reason, long lengths of small water pipes should be avoided, as should also any devices which, on account of corrosion, a lack of earth moisture, or for other reasons show a high resistance. Reliability at all times together with a minimum of care and inconvenience is the prerequisite of all such systems.

Various methods are employed in grounding, but it may be said that in general, they can all be classified under the following headings: Those making use of the building steel; those in which the ground conductor is connected to pipe lines, rails or other existing metallic circuits, and lastly those employing plates, pipes or other devices buried in the earth and used exclusively for grounding.

Grounding to the Building Steel

The grounding circuit in this case should be connected to the steel at the nearest point, long runs being avoided in order to reduce as far as possible the danger of a break in the circuit from outside causes. The conductor should be rigidly fastened to the steel by bolts, the surface of the steel at the point of contact having first been scraped clean of all paint or corrosion. An area of contact should be provided between the conductor and steel sufficient to render the resistance as low as possible. Where the conductor consists of wire or cable, lugs should be used at the grounding points.

Grounding to Pipe Lines

When the ground connection is made to pipe lines, water pipes should be used if possible. The pipe must

be large enough to carry any currents which may flow and the location of the connection should be such that the likelihood of a disconnection of that portion of the pipe for repairs or other purposes is remote. For this reason the conductor should be connected outside the water meter if the public mains are used. In all cases, the connection should be made as near as possible to the point where the pipe enters the earth. The connection may be made by a clamp or by a brass plug into which the conductor has been firmly soldered. If a clamp is used, it should be so constructed that by turning up on bolts or screws, it can be made to fit the pipe snugly. It should further be designed to afford a proper connection with the conductor either by a lug, if the conductor is of large cross-section, as shown in Fig. 2, or by a loop into which the conductor can be soldered, if of small cross-section, as shown in Fig. 3. The pipe, at the point of connection, should be scraped clean of rust, paint or other foreign matter before the clamp is attached, in order that the best possible contact may be made. The material for the clamp should be rolled copper. With such a clamp, the area of contact should be figured for a carrying capacity of 150 amp. per sq.in. For the cross-section, a capacity of 1000 amp. per sq.in. may be used.

If plugs are used they should be screwed tightly into a pipe fitting or into a hole tapped into the pipe itself if the latter is of cast iron. The practice of grounding to rails is so common as to call for but passing comment. It finds its chief application in the grounded return circuit of electric-railway systems. On such a system the rails may also be used for protective grounding.

Ground Plates

In the use of devices employed exclusively for grounding, the construction depends largely upon the condition of the soil, upon the proximity to a body of water, upon

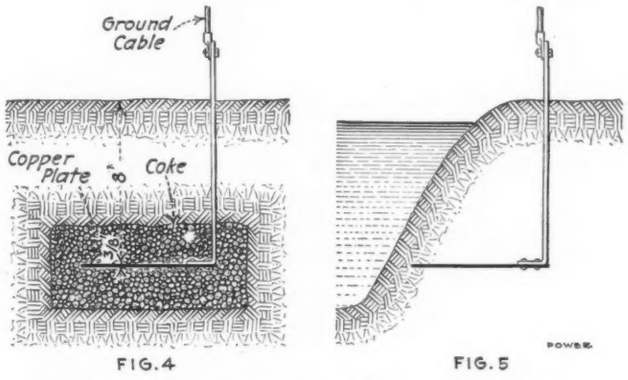


FIG. 4 FIG. 5

Grounding Plates Imbedded in Earth

the nature and extent of the various circuits connected thereto, and upon the personal tastes of the designer. One of the most widely used and approved devices consists primarily of a copper plate, as shown in Fig. 4. It should be of a thickness sufficient to prevent it from soon being destroyed by corrosion and also to afford sufficient mechanical strength. A thickness of from ¼ to ⅜ in. will suffice for most cases. For the best results, the plate should be located, if possible, in a place where the earth is permanently damp, and placed about eight feet below the surface. Around the plate on all sides should be placed a quantity of crushed coke, and to the plate should be securely fastened, preferably by rivets, a piece of copper bar or cable of a length sufficient to allow it to protrude a short distance above the surface of the earth. Iron pipe should never be used for a covering of this conductor if the latter is to be connected to lightning arresters. This is because of the impedance or choking effect which the iron pipe would exercise against oscillating currents. If pipe is used at all, it should be of brass. After the coke has been placed around the plate, it should

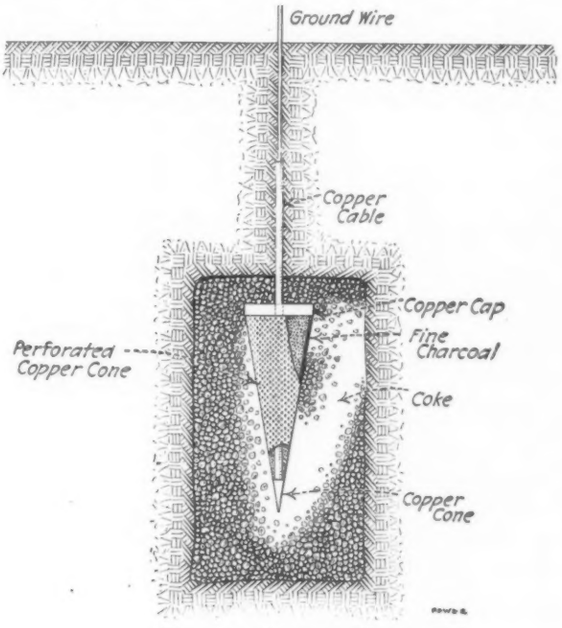


Fig. 6. Ground Cone

be thoroughly moistened before the hole is filled with earth.

Another method of grounding by a plate in locations where a stream or other body of water is available, consists in placing a copper or iron plate in the mud at the bottom or along the banks, as in Fig 5. The plate should be buried to a depth sufficient to prevent it from being disturbed. Rocky bottoms should be avoided if possible. The plate should never be suspended nor should it be allowed to rest lightly on stones or gravel.

Another method in common practice consists in the use of iron pipes driven into the earth for a distance of about eight feet. The earth should be as moist as possible. To insure a good contact, it is well to pour a quantity of salt water around the pipe. This procedure can be facilitated by having the lower end pointed and perforated. The salt water can then be poured into the pipe and diffused into the earth about the lower end of the pipe which is difficult to reach otherwise. In the use of pipes it should be borne in mind that enameled conduit ought never to be employed because of its insulated condition.

Ground Cones

A device for which good results are claimed consists of the ground cone, a leading form of which is constructed as shown in Fig. 6. It consists essentially of a perforated hollow copper cone filled with fine coke or charcoal and having at its apex a copper point to which is attached a copper cable. A copper cap fits over the top of the device, as shown. The ground conductor is soldered to the cable. A quantity of coke placed around the cone improves the efficiency, but is not absolutely nec-

essary. The function of the charcoal or coke within the cone is to absorb moisture from the surrounding earth, thus insuring good contact. The perforations allow this circulation of moisture and also render a more pronounced contact between the copper and its surrounding elements.

Grounding of Secondaries

This subject has been much discussed in recent years, owing to the varied opinions as to the advisability of the procedure. However, it is now commonly conceded that the grounding of transformer secondaries which supply current to customers and which carry voltages of 150 or less should be mandatory and that beyond that voltage, it may be permitted up to a voltage of 250. The object is to reduce as far as possible the danger to life and property which otherwise would result from a breakdown of insulation and the consequent crossing of transformer primaries and secondaries.

The usual procedure on systems employing a neutral is to ground the latter. On a single-phase system with a three-wire secondary, this can be done, as shown in Fig. 7, where one transformer is used, or, as shown in Fig. 8, if two transformers are used. If a neutral is not available, one side of the system should be grounded, as in Fig. 9. In Fig. 10 is shown a grounding connection for a two-wire, single-phase system with two transformers whose primaries are connected in series and the secondaries in multiple.

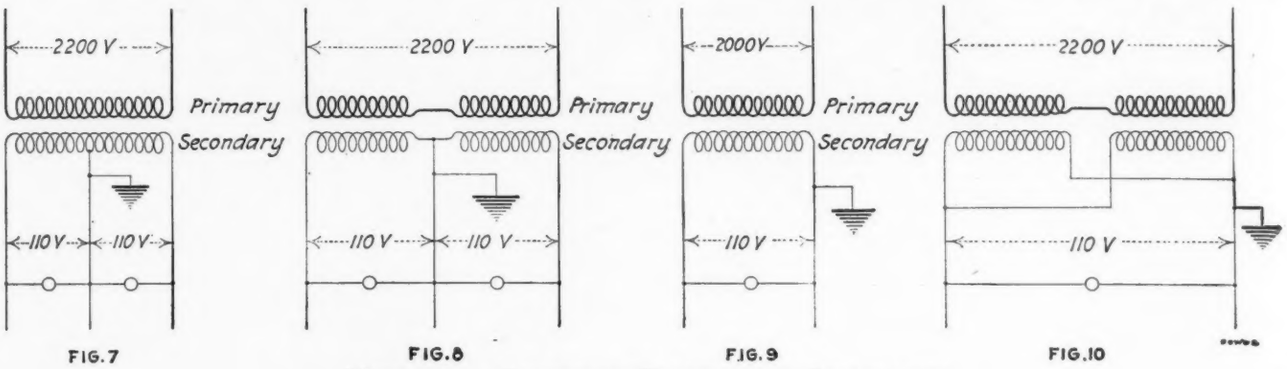


FIG. 7 FIG. 8 FIG. 9 FIG. 10

Methods of Grounding Transformer Secondaries

Smoke Formation and Prevention

The formation of smoke is due to failure to burn the combustible gases which are driven off from fresh bituminous coal (or other fuel of similar characteristics) when it is exposed to the heat of the furnace. These gases are a complex mixture of various hydrocarbons, from some of which carbon separates on cooling, in the form of lampblack or soot. The smokier fuels also give off tarry vapors, which condense and help to gather the carbon particles into flakes or "smuts."

For the burning of these gases as they are evolved from the coal, three conditions must exist: Air must be supplied above the fuel bed, the temperature must be high enough to insure ignition, and there must be time or space for combustion before the mixing currents of gas and air are cooled by flowing into or among the tubes of the boiler.

The surest way not to meet these requirements is to fire coal in large quantities at a time. This causes the temporary production of so much gas that neither air supply nor combustion space can possibly be sufficient for its burning; it also aggravates the trouble by cooling the furnace below the temperature of assured ignition.

With ordinary hand-fired furnaces, the formation of smoke can be greatly diminished, if not almost prevented, by putting on coal in small amounts at short intervals, with proper regulation of air supply. Much depends upon the kind of furnace. A roomy one, with brick walls and perhaps a brick arch roof (these being hot enough, in service, to ignite gas), is inherently less likely to give off smoke than a low furnace, especially if it has the water-cooled walls found in internally fired boilers.

The rate of combustion has an influence similar to that of the size of the combustion space. Then as a boiler is more heavily loaded, there is more chance for benefit from some one of the many schemes that have been proposed for injecting jets of air above the fire. The action of these jets in stirring and mixing air and gas favors rapid combustion.

There is a limit to frequency of firing by hand, in the strain it entails upon the fireman and in the undesirability of having the furnace doors open so much of the time. The necessity of compromise with these elements is eliminated by the use of mechanical stokers, which offer an effective means for securing and maintaining proper conditions of combustion.

On general principles, it matters but little whether the stoker is of the back-feed type, with the bed of fire slowly moving forward, or of the underfeed type. The essential thing is the continuous supplying of coal, without disturbance of draft conditions (by opening of doors) and with but small and slow variations in requirements as to proper air supply.

Coke-Oven Gas for Steam Generation—Extensions are to be made to the Dunston Power Station, near Newcastle-on-Tyne, which will be remembered in connection with some of the best turbine efficiencies that we have published. An agreement has been entered into by the Newcastle-on-Tyne Electric Supply Co., Ltd., with the Teams By-Products Co., Ltd., to purchase the surplus coke-oven gas from a large battery of ovens situated about 1½ miles from the Dunston Station. The gas will be used as fuel under the boilers. Extensions to the generator plant will consist of a 12,000-kw. turbo alternator, built by Brown, Boveri & Co., and run by a Richardson-Westgarth & Co.'s turbine.

Editorials

A Helping Hand

In the cartoon this week is indicated a good combination to assist to success the chap who is not afraid to shoulder a little responsibility. It used to be thought that theory and practice were about as harmonious as a losing baseball team is with the umpire. It was thought that "theoretically" and "practically" referred to two entirely different conditions and were in two different worlds.

The beetle-browed practical man of the old school—"no school" would perhaps be a better term—noticed that the textbooks began a severely practical question with such words as "disregarding friction." It also came under his observation that machines have an unshaken determination to regard friction. So he considered the theory to be wrong and worthless.

If this old scholar—or "no scholar"—had an engine with its valve-gear removed, he would not junk it as worthless. But that is what he is doing with his theory when he discards it simply because it is incomplete. Fortunately, the junk heap is more littered with specimens of his kind than with discarded theory.

Nowadays the man on the job is more or less of a theoretician or a failure. Even the dyed-in-the-wool practical man, if successful, knows more theory than many a college cub.

Don't junk your theory, even if, at the time, it doesn't deliver just the goods wanted. Save it until you can use it.

⁂

Two Startling Suggestions

When fuel is burned under a boiler more or less of the heat is dissipated before it gets into the water, and the products of combustion, bearing more or less heat, have to pass off by the chimney. In the Brünler system, described by Geheimrath Jaeger in the *Zeitschrift für Dampfkessel und Maschinenbetrieb,* the fuel, coal tar, is burned under water and under pressure, the products of combustion going with the steam into the engine. Air for combustion must, of course, be supplied under pressure, but by expansion in the engine or turbine it gives back the work required to compress it.

Another startling suggestion is to substitute mercury for water as the working fluid of a heat engine. The efficiency of a heat engine is measured by the temperature range through which it can be worked, and as the attainable low temperature is fixed by our environment, high efficiency involves a high initial temperature. With water, the pressure goes up rapidly with increasing temperatures, being 200 pounds for 382 degrees, nearly 250 pounds for 400 degrees, 421 pounds for 450 degrees, 684 pounds for 500 degrees, etc. With such a rapid increase in the pressure, per additional degree, a practical limit of pressure is reached at a comparatively low temperature.

The boiling point of mercury, however, is 680 degrees at atmospheric pressure. The idea is to generate mercury vapor under pressure, work it in an engine, exhaust it through a heater, where it is still hot enough to make steam of considerable pressure, but in which it will be condensed. The steam is used in a turbine.

This constitutes a binary vapor engine with water as the lower pressure fluid, whereas in that of Professor Josse the water is the higher pressure fluid, and bisulphide of carbon or some other fluid having a low boiling point the secondary.

The water or mercury vapor could itself be expanded to the lowest available exhaust temperature, but it would take on a volume which would be impracticable to handle. This lower volume at low pressure is, in the Josse engine, made to pass its heat to the volatile fluid, which, with the same heat at the same temperature, generates a small volume of vapor at a high pressure, available for further expansion in a cylinder of practicable dimensions.

⁂

Technical Methods in Boiler-Room Operation

More and more attention is being given to steam generation, for power-plant officials and owners are gradually realizing that in the boiler room is spent the greater part of the cost of power production.

That power-plant men have arrived at this point and are adopting more scientific and uptodate methods, are hopeful signs of the progress being made in power-plant engineering. Yet, it may be asked, "What percentage of the power plants throughout the country of any considerable size are properly equipped to take advantage of technical methods of operation?

While the subject of combustion has received more or less consideration, still it is safe to assert that not 10 per cent. of the chief engineers in the United States are able to operate an Orsat apparatus for the analysis of the gases passing through the flue. This condition is not past mending, as the signs of the time are toward constant betterment and a rise in the technical status of engineers. Those of the rising generation are qualifying themselves by study and investigation to bring the engineering profession to the high level where it rightly belongs.

No engineer is fully competent to manage a boiler plant, particularly a large one, who is unable to manipulate an Orsat apparatus and correctly interpret the information obtained from it. He should be able to determine the British thermal units per pound of fuel by the use of a calorimeter, and also the percentage of moisture, ash, sulphur, etc. He should know how to make a quantitative, or at least a qualitative, analysis of the boiler-feed water and of the scale found in the boilers, and to at least provide suitable temporary treatment. These requirements may appear excessive, yet, with diligent study these things may be accomplished in a short time by any man of the caliber required for this important branch of steam engineering.

The analysis and treatment of boiler-feed water does not always require the services of a chemist versed in all the branches of organic and inorganic chemistry, and the same holds good with the testing and analyzing of fuel. An engineer at present in charge of a large boiler plant took up the study of these branches some three years ago, and was able to make his analyses check closely with those of the professional chemists.

These technical methods of plant control are of proved value to the engineer.

The Responsibility of the Engineer

At a recent gathering of engineers, a distinguished designer of electric machinery opened his private records and data and discussed frankly the wreck of a generator, for the design, construction and test of which he was solely responsible. The speaker showed photographs of the plant before and after the disaster, lantern slides of the machine's construction, a typical polepiece lamination and other details of interest, practically laying bare every circumstance associated with the unfortunate event and magnanimously assuming the lion's share of the blame for what might have been a terrible fatality. Plainly everyone present was impressed with a realization that the lessons of failures and operating troubles are invaluable to all who are striving for perfection in their tasks and that the responsibilities which must be carried by every designer, builder and user of high-powered generating machinery are great.

Terrific forces are held in leash in a generator of the size involved in this accident, 9000 kilowatts. Built for operation by a waterwheel at 300 revolutions per minute, the peripheral velocity of the rotor was about 175 feet per second, which, at the time the generator was designed, was daring. The rotor was a solid disk, a nickel-steel forging, bolted to two shaft or journal ends. On each side of the solid disk was bolted an annular nickel-steel forging about nine inches wide and into the rotor were dovetailed ten polepieces weighing 5000 pounds each. The radial force on one of these polepieces reached the enormous total of nearly three million pounds with the machine operating at normal load and speed. During the test the unit was being speeded toward the specified maximum of 500 revolutions per minute, when, at 460 turns, one of the rotor forgings burst and the machine was wrecked, fortunately with no loss of life.

The accident afforded many lessons for the designing engineer, which the operating engineer also may take to heart in dealing with the important problems of purchasing apparatus and supplies.

What precautions are needed to avoid recurrences of this sort? First, in dealing with high-speed machinery, whether on the designing board or in the plant, whether in process in the factory or assembled in the test room, the limitations of employees having to do with such apparatus should be known by the man finally responsible. Some one solely responsible should see that the calculations of the designer are checked by the highest authority obtainable, that the quality of materials furnished is equal to that demanded by the specifications, and that the fabrication of material subjected to heavy mechanical or electrical strains accords with the latest knowledge regarding the effects of manipulation, heating, cooling and tooling upon the material dealt with.

Where heavy high-speed machinery is involved no detail of working the stock which goes into its structure is beneath the attention of the wise purchaser. Such an apparently trifling detail as the omission of a fillet or the marring of a bulky nickel-steel casting by tool marks may lead to disastrous results. Too much faith in the assurances of the manufacturer as to the reliability of parts or material to be used in lines outside those immediately familiar to him is likely to lead the engineer astray, and an easy-going dependence upon former practice without independent criticism of its adaptability to the new conditions is rash.

The engineering industry owes a debt to science for the fundamentals of its progress and in the intense commercialism of the present day it needs more of the true scientific spirit in attacking new and difficult problems which never can be solved on the bargain-counter basis. This does not mean that reliance cannot be placed upon manufacturing concerns of long-established reputation in filling the requirements of the operating engineer, but it does mean that where very striking departures from previous practice are indicated as desirable, either in method, design, size of equipment, factory treatment or acceptance trials, sole dependence safely cannot be placed upon the organization supplying the apparatus. Either one of the purchaser's staff, or his consulting engineer, should investigate the problem, not upon the basis of "who is right and who is wrong," but upon the much more important guidance of "what is right and what is wrong."

The Language of Ordinances

How easy it is not to say what one means is instanced by the first section of an ordinance recently adopted by the council of the city of Reading, Penn., providing for the inspection of steam boilers and the examination and licensing of engineers.

BE IT ORDAINED BY THE COUNCIL OF THE CITY OF READING, that the office of boiler inspector be and is hereby created, whose duty it shall be to issue a license to any applicant therefor who has charge of or operates a steam boiler or steam engine over 10 hp. in the city of Reading, etc.

To say nothing of the fact that the "whose" refers, in the letter—but not in the intent—of the ordinance, to the office instead of the inspector, the section as read makes it the duty of the inspector to issue a license to any applicant therefor, and the succeeding sections do not make this any less mandatory. The second section says that it shall be unlawful, etc., for one to run a boiler or engine, unless such persons shall, on or before Feb. 1, 1914, apply to the boiler inspector of the City of Reading for a license. who (the license ?) shall upon a proper examination of the applicant, grant him a license for the term fixed by said act.

While the intent of the act is perfectly clear, it would have been better to have expressed that intent grammatically and precisely. The salary of the inspector is fixed at the sum of $1500 per annum. It is to presume that this is simply an office which can be filled in connection with other duties. To specify such a salary as compensation for the full time of a man who is in supervisory charge of all the engineers in Reading, would be to set a miserably low standard for the wages of the craft in that community.

Correspondence

Removing Frost from Direct-Expansion Coils

The opinions in the Feb. 7 issue as to the merits and demerits of thawing refrigerator coils with hot gas as described by Mr. Thurston, in the Jan. 6 issue, were interesting. I have used this method for over fifteen years and have made provision for it in every plant of which I had charge, including packing-houses, cold-storage, brewery and ice plants. It is not only the most effective but also the cheapest and quickest way of thawing all direct-expansion coils; it is also safer, if the system is installed and operated properly, than knocking or scraping off the ice.

If the plant is large, the main hot-gas pipe should be of 2-in. size and the branch pipes 1¼ in. in diameter between the expansion valve and the cooling coil. If the main line is of considerable length or runs through cold rooms, it should be insulated. In our plant, I have installed two hot-gas main lines, 150 ft. long, 2 in. in diameter. They are not insulated pipes and the loss of heat before entering the 2-in. coils is not enough to warrant the expense of insulation. There is little heat lost because the gas is superheated.

To thaw ice from the coils, I first close the expansion and the return valves, then open the 1¼-in. valve gradually to avoid the hammering in the coil caused by the oil and foul liquids which are present in almost all coils. While the hot gas is slowly flowing into the coils I open the return valve and regulate it so that the suction pressure increases not over 2 lb. above the usual pressure. This increase of pressure, and therefore increase of temperature, of the ammonia within the system from which the coils are cut off, will not seriously affect the temperatures in the other coolers. I have not had as much as ½-deg. F. increase in any room during the thawing.

Wherever practical, the freezing coils in the different rooms should be divided into two or more separate coils, thus keeping the one coil going while thawing the other. Mr. Solomon's practice of knocking or scraping off the ice is dangerous, for the coils may be corroded, and serious leaks result from this practice. This cannot happen if hot gas is properly used.

WILLIAM SCHLIEMANN.

Washington, D.C.

Replying to Mr. Ohphuls' comment, I willingly acknowledge that frost may be removed with hot gas, but I contend that it is a poor way of doing it.

Suppose an ice machine is working on six freezer rooms to be kept 10 deg. F. above zero, and they are piped with 2-in. direct-expansion coils having a coating of hard frost about an inch thick. It is decided to thaw the frost from the coils in one room with hot gas. The suction valve is first closed and the hot gas allowed to enter the coil. This gas will condense into a liquid as soon as it enters the frosted coil in the cold room. The liquid will again evaporate as it travels through the pipe and will not have done any thawing so far. The temperature in the coil will have to be raised to cause thawing, and to get this sufficiently high temperature, the pressure will have to be about 50-lb. gage in the coil. To get this pressure in a cold room, the coil will have to be nearly filled with liquid; then, and not before, the frost will begin to drop off.

How much work will the ammonia compressor be doing on the other five rooms? Not much, for the working charge of ammonia will be so small that the machine might just as well be shut down entirely. It will take quite a long time to fill the coil with liquid by using hot gas and, as that is what must be done in the end, I think that the quickest way will be to use liquid from the receiver through the regular expansion valve. Do not expect to work the expansion valves on the other rooms while nearly all the ammonia is working as a frost remover.

My experience teaches me that the best way to combat the frost evil in cold rooms is to clean the frost off at regular intervals with scrapers. Do not let the frost become heavy as it will act as an insulator. When the frost is an inch thick, at the most, it is time to clean it off. A steel scraper bent to fit the pipe will do the cleaning quickly, cheaply and safely. Do not hammer the coils, for leaks are likely to develop in the pipe seams.

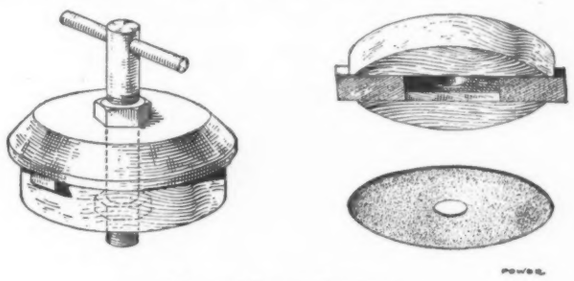
A. G. SOLOMON.

Chicago, Ill.

A Valve-Seat Dresser

I had a large boiler-feed pump, the valves and seats of which were badly scored. The seats were merely round bushings of brass, which I attempted to remove and dress in the lathe, but not having the proper tools, I had to do the job another way, which I will try to describe.

I first found a cast-iron disk 5¼x1¼ in. and faced one side off in the lathe, then drilled and tapped it for a ⅝-in. bolt with a long thread and locknut on the top side. I then fastened to it a piece of ⅞-in. pine board and turned it down to a disk 4 in. in diameter to serve as a guide. In the side of this board next to the disk I cut a groove 1¼ in. wide by ¼ in. deep, shown in Fig. 1. I



VALVE-SEAT DRESSER

next broke off two pieces of a bastard file each 2¼ in. long and clamped them in place as shown. At first I tried to use a tee handle, but found it unhandy, so I ground

the bolt down to fit into a bit brace, and it worked better. The files were used for the rough cut, then disks of medium emery cloth were substituted to finish the job with. After I had faced off the metal valves, the job was satisfactory and the cost small.

Worcester, Mass. W. E. CHANDLER.

Testing Valve for Leakage

Mr. Rae says on p. 96, Jan. 20, that the pressure dropped from 85 to 70 lb. the first day when he closed the top valve on the water glass. My opinion is that there must have been a little leakage of air or water, which would make the pressure drop. There was no leakage in the glass column, therefore the air would force the water out of the glass into the receiver until the pressures in the receiver and glass balanced. As the drop of pressure was 15 lb., all the water and some of the air would go into the receiver before equilibrium was established.

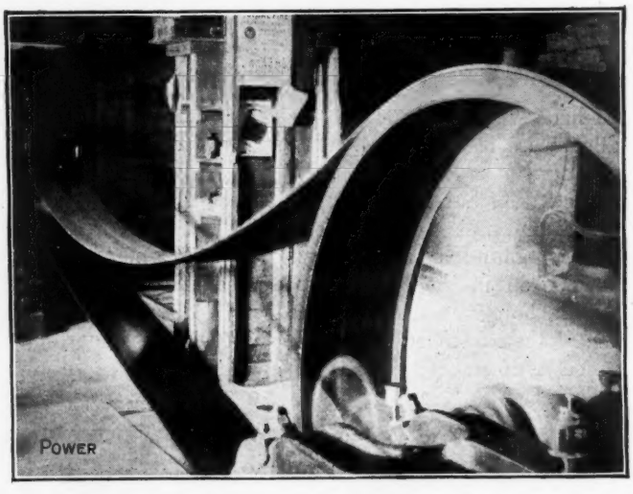
In the second tests, there was no leak to speak of in the chamber, but the air in the glass column must have escaped and the pressure in the chamber forced the water to fill the whole glass. Had the gland nut at *L* been tight in the second test, the water would have remained at its normal level, provided the chamber lost no pressure.

Ladysmith, B. C., Can. W. A. COOIL.

Belt Capacity

The following rule for belt capacity has been going the rounds of the technical press:

Multiply the belt speed in feet per minute by the width in inches. The result will be the energy in watts that the belt can safely be relied upon to transmit.



A 16-IN. DOUBLE BELT TRANSMITTING 74.6 KW. RUNNING SLACK

According to this rule, a 16-in. belt, running at 3200 ft. per min., would transmit only some 51 kw. The accompanying photograph shows a double leather belt 16 in. wide, running in the plant of the Woodbury Granite Co., Bethel, Vt., between the 13-in. pulley of a Westinghouse motor which runs 900 r.p.m., to the 78-in. pulley of an air compressor, and pulling 74,600 watts (when photographed) instead of the

$$\frac{16 \times 11 \times 13.5 \times 900}{12} = 50{,}900 \text{ watts}$$

which the rule allows. The photograph shows that the belt is carrying this load easily and with plenty of slack.

Another belt in a Canadian plant, also driving an air compressor, is carrying 61,200 watts, instead of only the 30,000 watts which the rule would allow.

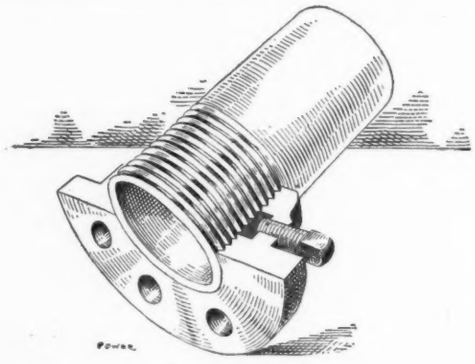
It is true that when the first belt was run tight, the tension being secured by turning up the screws in the base of the motor, it slipped and burned. But these two cases (and we can refer to numerous others) bear out our contention that a belt so treated that it can be run loose and yet have sufficient adhesion to the pulley, will give more and better service than a hard, slippery belt under excessive tension.

WILLIAM D. YOUNG.

Buffalo, N. Y. Cling-Surface Co.

Thread Leakage Prevented

Among engineers there arises discussion as to how to prevent thread leaks at the pipe end which is screwed



LEAD FILLER

into the hub of the flange. F. R. Maw's idea, page 932, Dec. 30 issue, is not bad, but I do not think it will answer for all uses and temperature changes, especially where the line is run outside and without covering.

The illustration shows a flange which, when properly made, will stand a pressure of steam or boiling oil in any temperature; the flange has a recess which is filled with lead. Setscrews are provided according to the size of the flange (one, two or three), and when the pipe is screwed into it the setscrews are tightened up, so that the lead is forced into the threads with considerable pressure, making them leakproof.

J. G. KOPPEL.

Sault Ste. Marie, Ont., Canada.

[There are similar fittings on the market.—EDITOR.]

Faulty Oil-Engine Diagrams

There appears to be something wrong with R. C. Hay's diagrams, Figs. 2 and 3, in the Feb. 3 issue (herewith

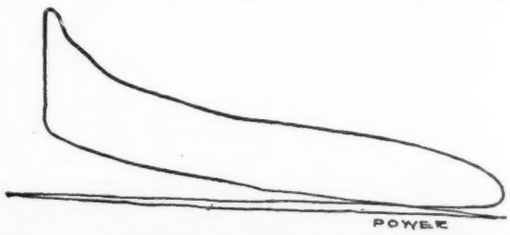


FIG. 2. DIAGRAM TAKEN BEFORE CHANGING ELBOW IN MUFFLER

reproduced). In Fig. 2 the exhaust stroke is considerably longer than the compression stroke and in Fig. 3 the exhaust stroke is shorter. This is impossible in most modern gas and gasoline engines. I can understand why Fig. 3 might have been as it is, but I cannot account for

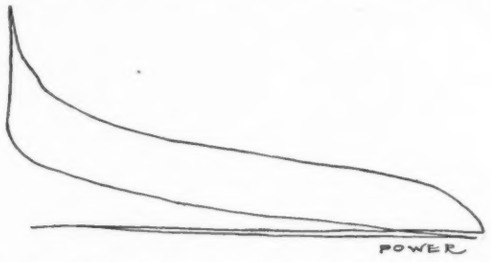


FIG. 3. DIAGRAM AFTER CHANGE IN MUFFLER

the diagram in Fig. 2. A similar diagram appears on page 241, of the Feb. 17 issue.

Furthermore, I cannot see why there should be a difference in the peaks and in the compression curves as Mr. Hay shows. To me, both should be either pointed, like Fig. 3, or rounded, like Fig. 2.

S. F. WILSON.

New York City.

Cause of Pound in Engine

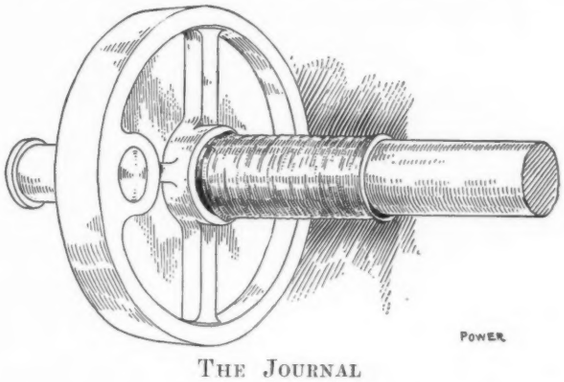
A Corliss engine pounded badly at the crankpin, and tightening the adjusting screws or giving more or less compression had no effect. The puzzling part was that we could draw up tightly on the adjusting wedge and the bearing would not heat. At the first opportunity the bearing was taken apart and it was found that as a shoulder had formed on the back of the brass, the adjusting wedge could not be pulled up past it.

H. A. JAHNKE.

Milwaukee, Wis.

Maltreatment of Apparatus

Henry W. Wetgen's article, in the Dec. 16 issue, recalls my experience while employed in a machine shop. We had to rebabbitt the quarter boxes of the main bear-



THE JOURNAL

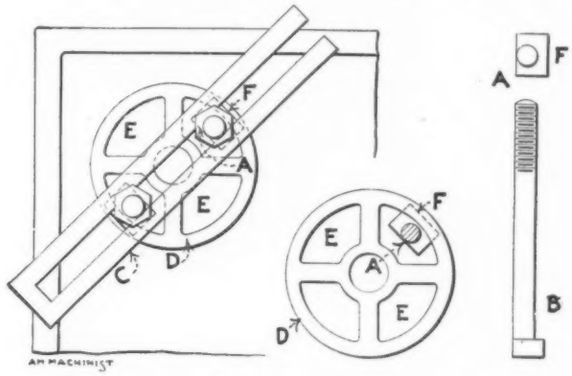
ing of an engine. The boxes were finished and delivered, but in a short time one of the side quarter boxes was returned with orders to plane $\frac{3}{32}$ in. off the back. We were told that we had put in too much babbitt, so that the two side boxes could not be entered. As we were sure the babbitting was all right, we sent a man over. He found that no scraping had been done on any of the four boxes to make a good fit on the shaft. There also was a high point on the shaft on both ends of the bearing due to wear, as shown in the illustration. After the boxes were scraped to a good fit they were put into place without trouble.

H. JAHNKE.

Milwaukee, Wis.

Tool for Removing Valve Seats

Those interested may be pleased to know of a simple device for removing pump-valve seats. It requires no skill



TOOL FOR REMOVING PUMP-VALVE SEATS

in iron working to make it, but a furnace fire, a grindstone or file, and a hammer are needed. Bend a piece of 1-in. iron U-shape, as shown. Take two bolts and file one side of each head, as shown at *A* and *B*, the diameter of the bolts to be a snug fit in the space *C*. Place the U-shaped iron over one corner of the valve chamber as at *D*. Put the bolt heads down through the ports *EE*. Let the side *F* go under the two inside rims of the valve seat. Put the nuts on the other ends of the bolts, screw them on and the valve seat will come out.

JAMES E. NOBLE.

Toronto, Ont., Canada.

Does Graphite Influence Corrosion?

The bottom of tin buckets in which I mix boiler graphite and water, I find soon rust or corrode through. Can some reader tell why this is thus?

R. G. LOVELL.

Courtland, Ariz.

Peened vs. Soldered Flanges

I disagree with F. R. Maw, page 932, Dec. 30 issue, as to his soldered joint. If there should be a slight vibration of the pipe it will tend to work the solder loose and then more calking will be necessary.

In my experience around steel and iron mills, I find that the following method is used with good results. Countersink the face side of the flange $\frac{1}{8}$ of an inch, screw the pipe in until it comes flush with the face of the flange (if the end of the pipe should project through the flange in making it up trim it off with a chisel), and with a ball peen hammer peen the end of the pipe out until it fills the countersink all the way around. I never saw any leaky joints when put up in this way.

St. Cloud, Fla. F. M. BENJAMIN.

Inquiries of General Interest

Flat Compounded Generator—When is a generator said to be flat compounded?

V. S.

When its shunt and series coils are so proportioned that the voltage remains practically constant at all loads within a predetermined range.

Air Chamber on Pump Suction—What is the purpose of placing an air chamber on the suction side of a pump?

S. D. N.

To obtain an air cushion for preventing water hammer caused by sudden checking of the velocity of the suction water when the pump piston stops or reverses.

Use of Rectifying Commutators—Why are not rectifying commutators used more extensively?

A. F. M.

With heavy currents and high voltages their use is accompanied by excessive sparking at the brushes and their employment is limited to small currents at moderate voltages.

Radiation of Heat from Oily Surfaces—What is the relative loss of heat by radiation from the polished surface of a cylinder head whether oiled or dry?

C. B.

The loss of heat from polished cast-iron cylinder head is about 2½ times as much per minute when moist with oil as when wiped perfectly dry.

Draft Gage Connections Must Be Tight—Should draft gage connections be made by straight pipes or may they be made with pipe bends and elbow fittings?

I. C.

As there is no flow through the connections they may be made with bends and fittings, but for correct draft-gage indications all joints must be perfectly draft tight.

Clearance of Valve with Pressure Plate—What should the clearance be for a balanced slide valve with pressure plate?

C. S.

The clearance should be only enough to compensate for any inequalities of expansion and for that purpose the distance pieces supporting the pressure plate are usually made about two one-thousandths of an inch thicker than the valve.

Pressure on Discharge Side of Induced Draft Fan—Should not the pressure on the discharge side of the fan in an induced draft system indicate a pressure above atmosphere because of the fan forcing the gases up the stack?

J. S.

The pressure may be greater or less than that of the atmosphere depending, for the given capacity of the fan, on the temperature of the gases and the size and height of the stack.

Joints of Brine Tanks—What is the object of using tarred paper between the joints of a steel-plate brine tank and how do such joints compare with ordinary riveted joints?

S. W. N.

In erecting brine tanks tarred paper is sometimes used as packing placed between the lap of joints that are bolted together, but such joints are not as good nor as durable as hot riveted joints made tight by calking the edges of the plates.

Ratio of Heating Surface for Factory Buildings—How many cubic feet of space are usually allowed per square foot of steam pipe radiating surface for warming factory buildings

S. R.

For average winter weather requirements of the northern states, and with average brick construction of factory buildings, ordinary exposures and good distribution of radiating surfaces, it is usual to allow a ratio of 80 to 90 cu.ft. of space to one square foot of pipe radiating surface, varying according to the exposure and uses made of the rooms which are heated.

Compressibility of Water—How much would a given volume of water be compressed if subjected to a pressure of 100 lb. per sq.in.?

E. R.

The compressibility of water is from 0.00004 to 0.00005 of its original volume for a pressure of one atmosphere, decreasing with increase of temperature. Allowing average compressibility of 0.000045 of volume for a pressure of one atmosphere and one atmosphere as equivalent to 14.7 lb. per sq.in., then for 100 lb. pressure per sq.in. a given volume of water would be compressed

$$\frac{100 \times 0.000045}{14.7}$$

or about $^1/_{3267}$ of its original volume.

Stack Size Using Oil Fuel—In a case where a 48-in. diameter stack 90 ft. high is suitable for a 350-hp. boiler burning bituminous coal, for what increase of boiler capacity would the same stack be suitable using oil as fuel?

J. G. S.

In burning oil owing to the smaller volume of gas formed as compared with coal, the forced-draft action of oil burners and the absence of obstruction to draft by grates and a bed of solid fuel, it has been found that for the same boiler capacity a stack of about 60 per cent. capacity is sufficient when burning oil. Therefore, a stack suitable for development of 350 boiler-horsepower burning bituminous coal with natural draft should be adequate for

$$\frac{350}{0.60} = 583$$

boiler-horsepower when oil is used as fuel.

Boiler Horsepower of Steam Required for Steam Kettles—Without allowance for losses of heat by radiation or by evaporation from the surface of the water, what number of boiler-horsepower would be required for heating in steam jacketed kettles, 3000 lb. of water per hour, from 62 to 212 deg. F.?

E. C.

Each pound of water would require 212 — 62 = 150 B.t.u., and for heating 3000 lb. there would be required

$$3000 \times 150 = 450{,}000 \text{ B.t.u.}$$

As one boiler-horsepower is equivalent to the evaporation of 34½ lb. of water per hour from and at 212 deg. F., each pound requiring for the latent heat of evaporation 970.4 B.t.u., one boiler-horsepower is therefore equivalent to

$$34\tfrac{1}{2} \times 970.4 = 33{,}479 \text{ B.t.u. per hour,}$$

hence to heat 3000 lb. of water per hour under the conditions stated would require

$$450{,}000 \div 33{,}479 = 13.4+ \text{ boiler-horsepower.}$$

Horsepower per Square Inch of Indicator Diagram—When a number of indicator diagrams are of the same length and taken with the same scale of spring, how would the horsepower constant be found per square inch of area of the diagrams obtained by a planimeter?

H. J.

The mean effective pressure of a diagram being its area in square inches divided by its length in inches and multiplied by the scale of the indicator spring, or

$$\text{mean effective pressure} = \frac{a \times s}{l}$$

then in the ordinary formula

$$\text{hp.} = \frac{P \times L \times A \times N}{33{,}000}$$

by substituting the value of the mean effective pressure for P we would have

$$\text{hp.} = \frac{\frac{a \times s}{l} \times L \times A \times N}{33{,}000} = a \times \left(\frac{s \times L \times A \times N}{l \times 33{,}000}\right)$$

and by making a = 1, the formula becomes:

$$\text{hp. for 1 sq.in. of diagram} = \frac{S \times L \times A \times N}{l \times 33{,}000}$$

i.e., the number of horsepower per square inch of area of the diagram is found by multiplying together the scale of the indicator spring and the length of the stroke in feet by the area of the engine piston in square inches and the number of strokes per minute, and dividing by the product of the length of the diagram in inches and 33,000.

Engineers' Study Course

Curve Plotting--III

From the preceding lessons we can conclude that all quantities may be divided into two classes: *constants* and *variables.* A constant quantity is one that maintains a fixed value, for example, the length of the stroke of an engine does not change. The speed and the load may change but the stroke remains the same under all conditions. A variable is a quantity whose value is changing. Variables may be subdivided into *dependent* and *independent variables.* Thus the mean effective steam pressure in an engine cylinder is a dependent variable, for its value is determined by the load on the engine. The load on the engine is an independent variable, for it can be changed at will. (In a sense the load is a dependent variable, as it is limited by the power of the engine.)

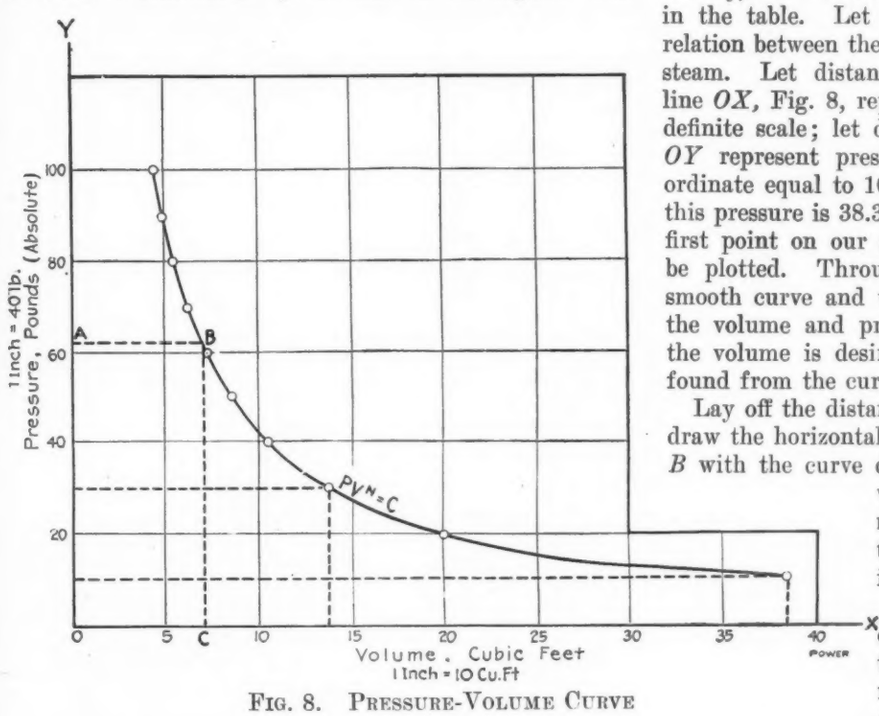


FIG. 8. PRESSURE-VOLUME CURVE

As explained in the second lesson, a physical law may be stated in the form of an algebraic equation, or it may be represented graphically by the aid of a *curve* or *graph,* and in most cases the latter method will give a clearer idea of the law of variation than will a mere setting down of the equation. Take, for example, the law of the expansion of gases which states that *the product of the absolute pressure times the volume is equal to the weight of the gas times the absolute temperature of the gas, times a constant which is dependent upon the gas.* Stated in the form of an equation there results,

$$PV = WRT$$

Assume W as unity and let T remain constant, and we have the well known *isothermal law* that *if the temperature of a gas remain constant then the product of the absolute pressure and volume of the gas will also remain constant.* This is the approximate law for the expansion of steam in the engine cylinder.

For every pressure, saturated steam has a definite volume, and a fixed temperature. These values have been determined largely from experiment. The following table gives the values of the volume for certain pressures:

Absolute Pressure	10	20	30	40	50	60	70	80	90	100
Volume, cubic feet	38.38	20.08	13.74	10.49	8.51	7.17	6.2	5.47	4.89	4.43

Frequently the engineer desires values not given in the table and is at a loss to know how to determine them. This gives rise to another useful application of curves, namely, the determining of intermediate values not given in the table. Let us now plot the curve showing the relation between the pressure and the volume of saturated steam. Let distances (abscissas) measured along the line OX, Fig. 8, represent the volume in cubic feet to a definite scale; let distances measured along the vertical OY represent pressure, to another scale. Lay off an ordinate equal to 10 lb. From the table the volume for this pressure is 38.38 cu.ft. These two values give us the first point on our curve and similarly other points can be plotted. Through the points thus plotted draw a smooth curve and we have a graphical relation between the volume and pressure of saturated steam. Suppose the volume is desired at 62 lb. pressure. This can be found from the curve as follows:

Lay off the distance OA (to scale) to represent 62 lb., draw the horizontal line AB; at the point of intersection B with the curve drop a perpendicular BC, cutting the volume axis at C. Then the line OC multiplied by the volume scale gives the desired volume which in this case is 6.95 cu.ft.

Another instance where a knowledge of curve plotting is essential is in the testing of boilers, engines, generators, motors, etc. A mere tabulation of the data taken during the test is of little value in giving a general conception of the performance of the given unit. The following table gives the results of a series of tests on a four-cylinder four-cycle Diesel oil engine.

Test No.	1	2	3	4	5	6
Kw.	..	31	71	109	150	169
Net b.hp.	2	50	111	163	220	246
R.p.m.	171	169	167	164	165	162
Pounds of fuel per b.hp. hour	..	0.77	0.48	0.45	0.44	0.444
Thermal efficiency	..	17.4%	27.8%	29.5%	30.3%	30.2%

In Fig. 9 let distances along the axis OX represent the net brake horsepower (b.hp.) to an assumed scale. Let the ordinates along OY equal the revolutions per minute to a definite scale. From the values given in the table locate the necessary points and plot the curve AB which shows at a glance the variation in speed of the engine as the load is increased or decreased.

It is often desirable to have on the same chart a series of curves showing the relation between the dependent and the independent variables. In a commercial test

the load is taken as the independent variable. In this case we will take speed, thermal efficiency and fuel consumption as the dependent variables. To plot these new curves the same abscissas (load) can be used, but new vertical scales must be assumed. At the right of Fig. 9 let distances along XY' represent thermal efficiencies

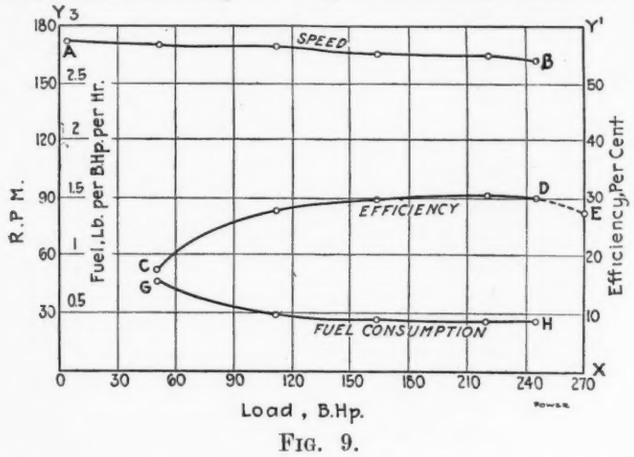


FIG. 9.

in per cent. to an assumed scale—one unit on this line will necessarily mean something entirely different from one unit on the line OY. Next take the values of the efficiencies from the table corresponding to the brake loads; locate a new set of points and through them draw the curve CD. From this curve we find that the maximum efficiency occurs when the load is 220 b.hp. The curve also shows how the efficiency decreases under light loads and also on the overloads.

There remains the fuel-consumption curve. Here, again, a new vertical scale must be assumed and will represent pounds of fuel per brake horsepower per hour. To avoid confusion it is well to mark the values for fuel

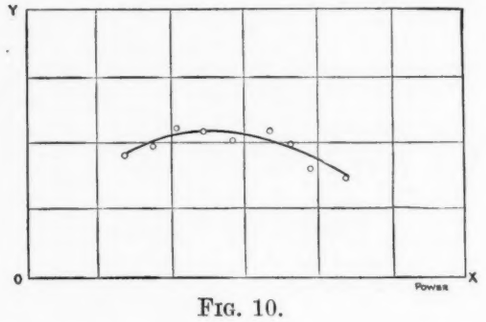


FIG. 10.

inside the line OY and keep the values of speed outside the line OY. Taking the necessary values from the table and plotting the points there results the curve GH. Still further curves might be plotted on this same chart. The student is urged to plot these same curves to different scales and compare the results.

By a careful study of the curves shown in Fig. 9 predictions can be made as to the probable values under other conditions of load. Thus if the net brake horsepower were run up to 270 (provided the engine would carry such a load) the efficiency would likely drop to the point E or about 27 per cent. This value is found by extending the curve to the point E by following the general outline of the curve CD.

In plotting curves of this type great care must be taken to select suitable scales or false deductions may be drawn from the results. No definite rules can be given as to what units should be used but it is hardly probable that we would take, say, seven or nine units per inch but rather four or eight, or still better multiples of ten. In choosing the scales two things should be borne in mind: (1) That the scales should be large enough to give the required degree of accuracy and (2) that they should not be so large as to separate the points of observation by great distances or to represent a degree of accuracy greater than the original figures. In all such cases the scales should be clearly marked upon the axes and both scales should start with 0 value at the origin or the intersection of the axes of X and Y.

At times when an attempt is made to plot a curve between two variables it will be found that a smooth curve cannot be drawn that will touch or pass through all the points of observation, due, perhaps, to unavoidable inac-

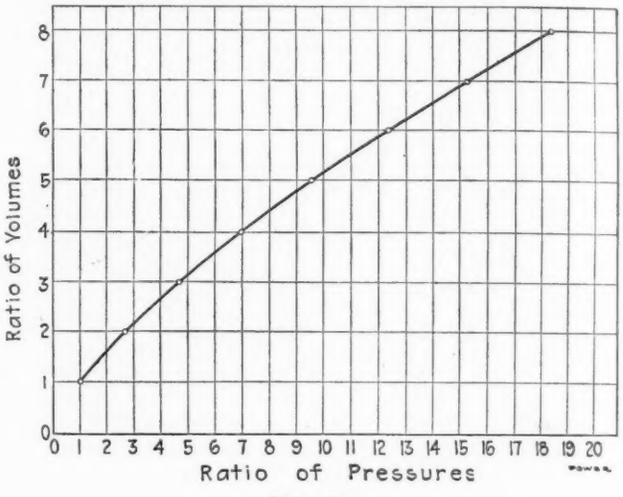


FIG. 11.

curacies in the readings. In such cases (see Fig. 10) locate all the points and mark them by a ∘ or +, and then draw a smooth curve, as shown, to touch on the average values or pass as near to them as possible.

As a final application let us consider the case of a gas engine. It is desired to find the probable pressure at the end of the compression stroke. The approximate law of compression is

$$P V^{1.4} = constant$$

Let the clearance volume equal V_1 and the total cylinder volume (piston displacement plus clearance) equal V_2. Let P_1 equal the pressure at the end of compression and P_2 equal 14.7 equal the pressure at the beginning of compression. Then

$$P_1 V_1^{1.4} = P_2 V_2^{1.4} \text{ or } \frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{1.4}$$

This makes a hard equation to solve and to facilitate computations of this character curves are plotted giving the ratio between pressures for given volume ratios. If the clearance is 33⅓ per cent. the volume ratio is then 4 and from the curve, Fig. 11 (plotted from computed data) the pressure ratio is approximately seven. Therefore, the pressure at the end of compression equals

$$7 \times 14.7 = 102.9 \text{ lb. abs.} = 88.2 \text{ lb. gage.}$$

From these illustrations we see that the plotting of curves is very useful to the engineer in helping him to interpret data from tests, to predict results under other conditions, to find intermediate values not given in tables and to aid in the solution of complicated ratios.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The editor of a Michigan paper, says "Factory," apologized for its late appearance as follows:

"The Times is late this week because our gasoline engine got a cranky streak. The more we cranked it the crankier it got. We unscrewed the umbilicus and took out the trajectory. This seemed to be all right and we concluded that there might have been a leakage of the synovial fluid through the pyloric orifice into the appendix. We had a deuce of a time removing the appendix with a monkey wrench and a cold chisel. There was nothing in it. There is a pipe that runs from the engine up through the roof of the press room. We had noticed when the engine was running that this pipe said 'kapunk' every time the clapper of the engine said 'kapeet.' We examined the kapunker and found that a swallow had built a nest in it. This solved the mystery. The engine couldn't 'kapeet' because the kapunker couldn't 'kapunk.'"

Don't be too humble—everybody steps on the doormat—"Obermayer Bulletin."

True for you, Sammy, but don't be too cocky, either, for many a man has gone to the mat for just this thing.

AN EFFICIENT CHECK VALVE

"You don't pass this door tonight, George William. This night work is ruinin' your health."

Wonder how an engineer was appointed as a master in chancery to determine what are the rights of the Arkansas Water Co. The lawyers had better look into this. They know little or nothing of engineering, but they get nearly all the fat jobs that pay anything. No, we're mistaken. Two photographers, a printer and an insurance collector have recently civil-serviced into a municipal ferry as deckhands.

Now and again, some power-plant man's wife writes us: "For my sake, do not send the paper any more; we can't even pay our household debts. Besides, Hubby never opens it." It seems that Hubby is a fireman and gets $12 a week. Poor wife! But ding bust you, Hubby! Probably if you had opened the paper and let some of it sink into your ivory toppiece, by this time you might be an engineer—a regular fellow, with real wages.

"Spizzerwinktum"—Now don't laugh! That's a real word, according to the latest "Standard Dictionary." It's a good word, too, because it means vim, ginger, energy, and all those things, and then some.

J-M Fyro Fire Extinguisher

A simple and efficient fire extinguisher, the J-M Fyro, discharges, by means of compressed air, a liquid gas said to be 40 times as effective as water. No mechanical force is required to operate it. It is only necessary to hold it upright and turn a small valve wheel.

This little fire-fighter, which is made by the H. W. Johns-Manville Co., Madison Ave. and Forty-first St., New York City, measures but 3x15 in. It throws a spray as well as a stream; the spray can be thrown a distance of 10 ft., the stream 25 ft. The spray is most effective on small fires, which are scattered over a comparatively large area; the stream is usually best for small, concentrated fires.

The advantage of the spray is that it will cover the blaze of the average incipient fire so that all of the liquid gas volatilizes. In so doing, the gas forms a dense combustion-arresting blanket five times as heavy as air. Because of its density and weight it quickly envelops the flames, displaces the oxygen and extinguishes the fire.

As the extinguishing fluid contains no water, it is a nonconductor of electricity and can accordingly be used in electric fires without danger of short-circuits. The fluid can also be used on gasoline and electric fires. As the fluid is noncorrosive, it does not cause rust, and will not injure the skin nor harm delicate fabrics or furnishings.

Compounding Simple Reciprocating Engines

BY JOHN S. LEESE

A plant of interest is that at the Bank Wood Mills, Stalybridge, Eng.

The power house contains four engines; Nos. 1 and 2 are geared to a common shaft from which one section of the mill is driven, and Nos. 3 and 4 to a shaft transmitting power to the rest of the mill. Engine No. 2 runs at high pressure to engine No. 1, forming a compound unit, and engine No. 4 runs at high pressure to engine No. 3, making a second compound unit.

All the engines are old. Engine No. 2, built in 1865, is of the true vertical type with the crankshaft above the cylinders, the head ends of which were bolted to the foundation plate. The two double-acting cylinders are 16-in. bore by 30-in. stroke, and the engine speed is 80 r.p.m. Engine No. 1 was installed in 1832, by James Watt & Co., of Soho Ironworks, Birmingham (formerly Boulton & Watt). It is an old-pattern side-lever marine engine, with two double-acting cylinders, 42-in. bore by 48-in. stroke, and having a speed of 38 r.p.m. The flywheels of both engines have toothed racks cut around their peripheries, and both are geared with wheels on one of the mill main line-shafts. Steam at 120 lb. is supplied to both cylinders of No. 2, which exhaust into a receiver from which the steam passes to both cylinders of No. 1, the receiver pressure being about 15 lb. Vacuum is maintained by a jet condenser at about 25 in.

No. 4 engine was a two-cylinder, horizontal Corliss type, with 17-in. cylinders and 30-in. stroke, running at 80 r.p.m. This machine was originally installed in 1864, but in 1892 it was practically rebuilt. Whether it had Corliss valves originally, I do not know. I was told that the only parts of the original engine which had been

retained were the crankshaft, connecting-rods and flywheel. Nobody knew the name of the original makers, though it was said to have been an American machine. Engine 3 was installed in 1845 by Hick & Co., of Bolton (now Hick, Hargreaves & Co., Ltd.), and is a two-cylinder, double-acting beam engine, 50-in. bore by 84-in. stroke, running at 21 r.p.m. It is of interest in that it is provided with steam-jacketed cylinders, and has the old type of packed D-slide valves. Engine No. 4 receives steam at 120 lb., exhausts into a receiver at about 10 lb. and runs as high pressure, the beam engine working as a low-pressure side of a compound unit. The beam engine exhausts into a jet condenser maintaining 27 in. vacuum.

The mill manager said that the average coal consumption of the plant was about 3 lb. per i.hp.-hr.; not a bad economy for a lot of engines of their age and condition.

The novelty of this old plant is that in each case, two twin-cylinder engines running at different speeds and of altogether different types, run as high- and low-pressure sides of a compound unit.

Economy of Rolling Mill Reversing Engine

SYNOPSIS—The competition between steam and electric drives for mills has been a healthy stimulus to the design of steam-reversing engines for rolling mills, with the result that the economy of such engines has been greatly improved.

Improved economy for the type is shown in the results from tests of a 46 and 76 by 60-in. twin, tandem, compound, reversing engine, Fig. 1, built by the Mesta Machine Co., Pittsburgh, for the Youngstown Sheet & Tube Co. Although this engine has been briefly described in a previous article, it is desirable to give in detail those features which have made this steam economy possible.

From Fig. 2, it will be noticed that there is but one controlling lever *A*, and that it operates the relay valve which, in turn, controls both the reversing links and throttle. When the main reversing lever is in position *B* or *C*, the throttle is wide open; in position *D*, it is closed. The steam pressure and the cutoff with which the engine works are therefore so interconnected, that at light and medium-heavy loads, the operator must work with a combination of throttle and cutoff control.

While operation with cutoff is theoretically possible with any two-lever reversing engine, it would require almost superhuman attention and skill from the operator and is therefore practically impossible. Investigation

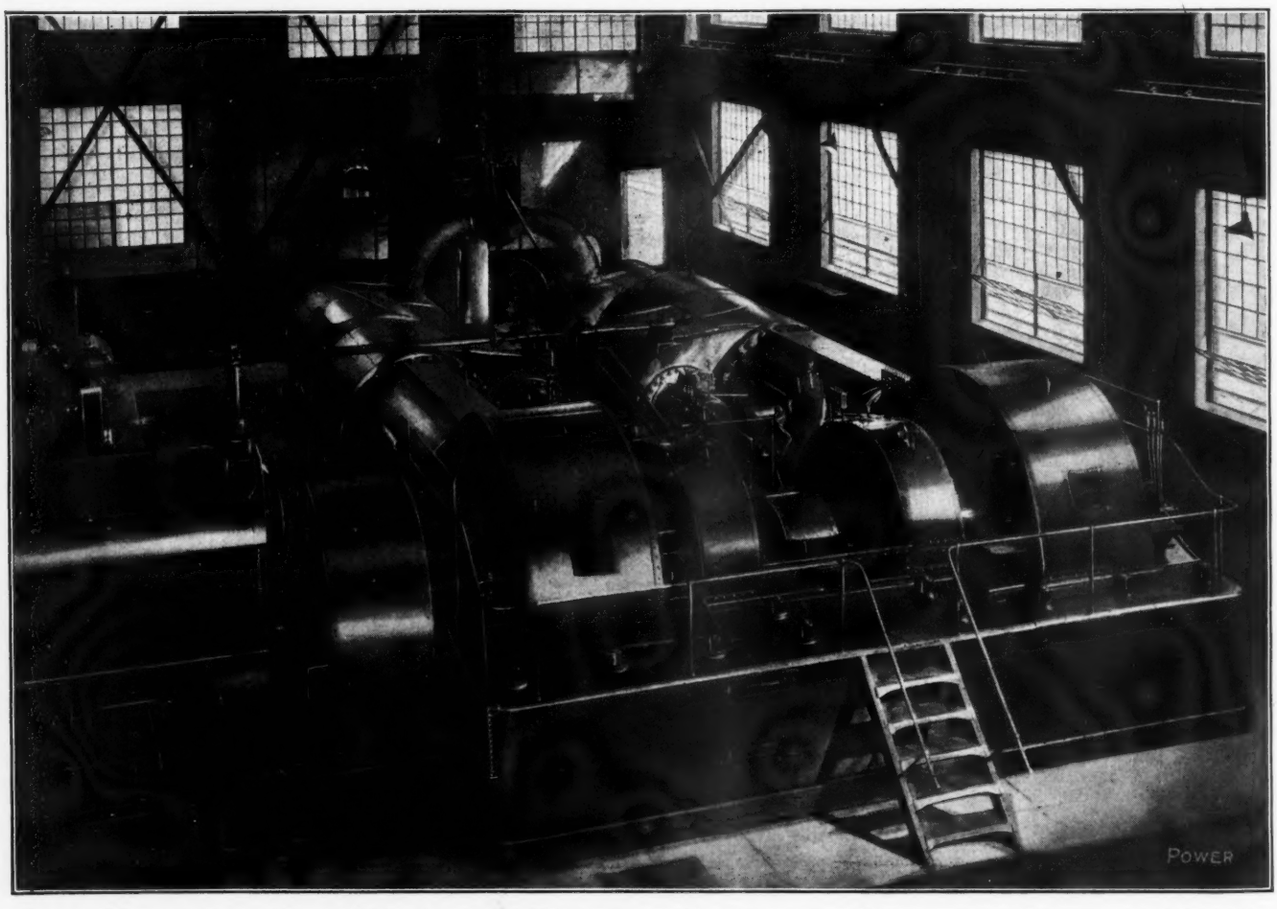


FIG. 1. MESTA 46 AND 76 BY 60-IN. REVERSING ENGINE AT PLANT OF THE YOUNGSTOWN SHEET AND TUBE CO.

shows that most operators give maximum cutoff at the beginning of the pass and then control by the throttle alone. The fact that cutoff is attained with the single-lever control is furnished by Fig. 3, which shows indicator cards selected at random from those taken during the test which is herewith described.

The opening of the throttle is not simultaneous with the movement of the reversing lever from the point *D*, for there is a certain idle stroke of the throttle valve. When the throttle opens, steam is admitted through the auxiliary ports in the bushings of the main piston valves. This combination of idle throttle-valve travel and auxiliary ports makes possible smooth and certain starting in any position of the cranks. These auxiliary ports admit steam during the regular operation of the engine—that is, during the rolling process—but while they are large enough for quick starting, they are too small to affect the shape of the regular indicator cards or the steam consumption of the engine.

The success of the engine depends not so much upon the mere presence of the auxiliary ports as it does upon the careful proportioning of the throw of the eccentrics, the length of the links, the size and location of the auxiliary ports and the shape of the steam ports in the bushing of the main throttle valves.

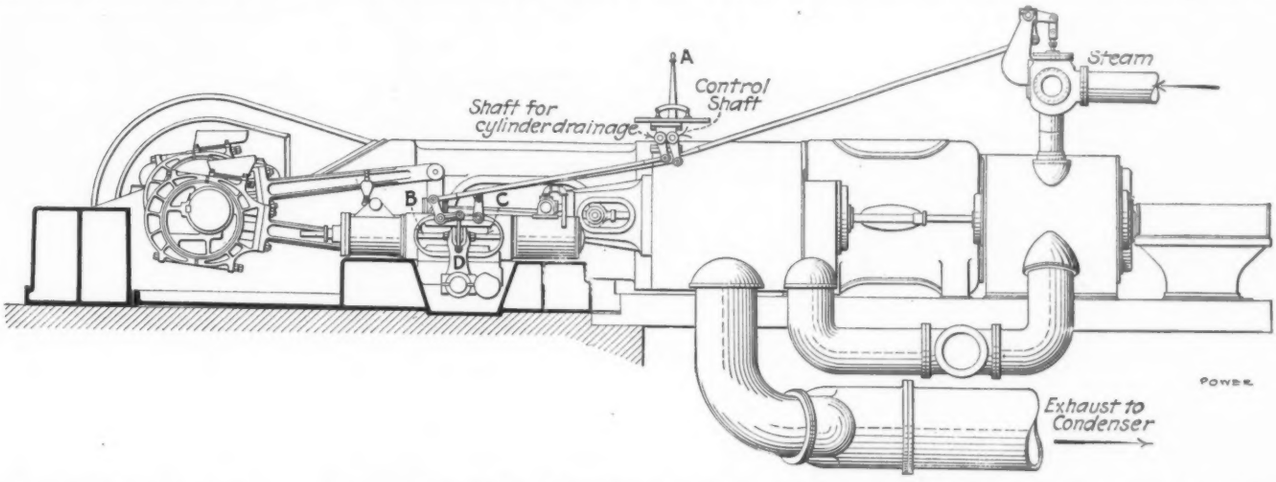


FIG. 2. OUTLINE OF 46 AND 76 BY 60-IN. TWIN TANDEM COMPOUND REVERSING ENGINE, SHOWING SINGLE LEVER CONTROL

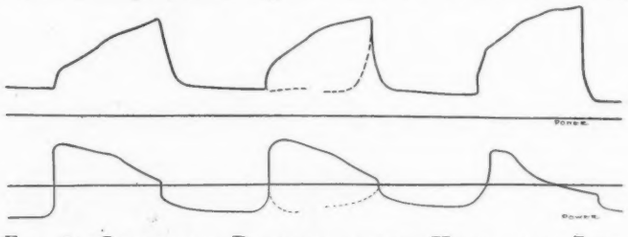


FIG. 3. INDICATOR DIAGRAMS FROM HIGH- AND LOW-PRESSURE CYLINDERS

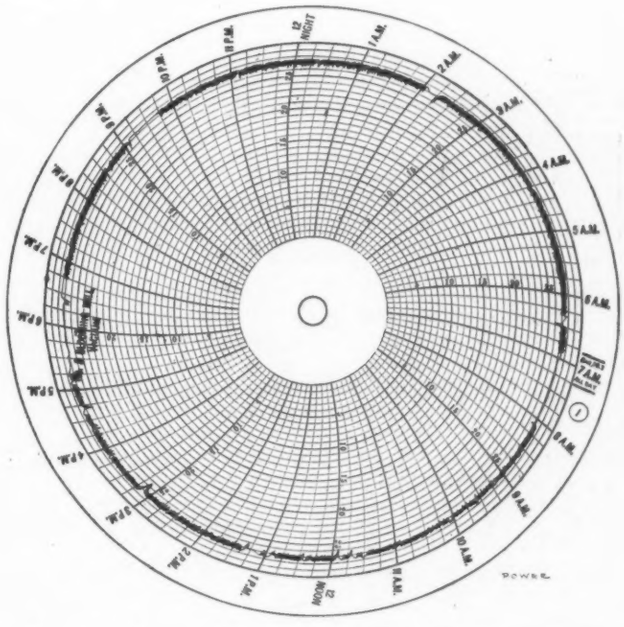


FIG. 4. CHART SHOWING SLIGHT VARIATION IN VACUUM

On Nov. 28 and 29, 1913, a test was made by engineers of the Youngstown Sheet & Tube Co., the Carnegie Steel Co., the Mesta Machine Co., and by professors and students of the Carnegie Institute of Technology. The test data and results were checked by all of the interested parties so that there could be no possibility of error.

The steam consumption of the engine per indicated horsepower hour was found to be between the limits of 20 and 22 lb., depending somewhat upon the method of rolling, so that 21 lb. may be taken as the average.

To make sure that the new method of control would allow sufficiently quick handling of the engine, the time for reversal was repeatedly tested. The average time of change from 60 r.p.m. in one direction to 20 r.p.m. in the other was found to be $2\frac{2}{10}$ sec. Since these speeds are ordinarily found at the end and at the beginning of the passes respectively, $2\frac{2}{10}$ sec. may be called the mean interval required by the engine for reversal. As a rule, the manipulation of the ingot takes a longer period than that required by the engine for reversal.

In connection with these test data, it may be of interest to note that obtaining them required simultaneous readings by 15 observers; eight at the continuous indicators; three on the pulpit; one for observing the temperature of the steel, two for observing the elongation of the steel, and one for taking measurements at the condenser. In addition, there was one general over-

seer of the test, while the weight and the chemical composition of ingot were obtained from the mill and the laboratory. Steam engineers and rolling-mill men are indebted to the Youngstown Sheet & Tube Co., for the generous manner in which it has made possible the running of such a test and for the publication of the results.

The results of this test show conclusively that the reversing engine, when correctly designed, need not fear the competition of electric drives, particularly since the remarkable economy has been attained without complication. The Mesta Machine Co. states that the engine contains fewer moving joints than the so-called standard, simple reversing engine and that consequently the cost of repairs and attendance has been correspondingly reduced. In fact, no keying up setting up, or repairing have been done on the engine since it was started in July, 1913.

Another noteworthy feature of the installation is the condenser, which was also built by the Mesta Machine Co. During the heaviest rolling, vacuum never leaves the range between 27 and 28 in. of mercury (referred to 30 in. barometer). Fig. 4 shows the vacuum in the condenser during its regular operation.

Applications of Combined Swing-Gate and Check Valve

By Oscar C. Schmidt

SYNOPSIS—Describes the various applications of the swing-gate and check valve as used in modern systems of piping.

The refinement which is taking place in power-plant equipment has spread, not only to the methods of power generation and transmission, but also to the smallest technical constructive detail connected with power-plant operation. While it is important that economy be considered in the design of any plant, it is also necessary to consider the safety details of each piece of apparatus used.

Among some of the power-plant safety devices are the safety stop, which is designed to prevent an engine from running away; the safety gage cock, which operates when the gage-glass is broken; the automatic relief valve, the check valve, and the nonreturn gate valve.

The swinging-gate and check valve is a safety device which is being used extensively to prevent disaster to the steam turbine, engine, pump, hammer, elevator and other types of steam and hydraulic apparatus. This type acts as a safety valve on any pipe line where it is necessary that the flow through the pipe shall be in one direction, and where disastrous results would follow if the medium were allowed to flow into the pump or engine cylinder in a direction contrary to the normal flow.

The extensive use of the condenser and feed-water

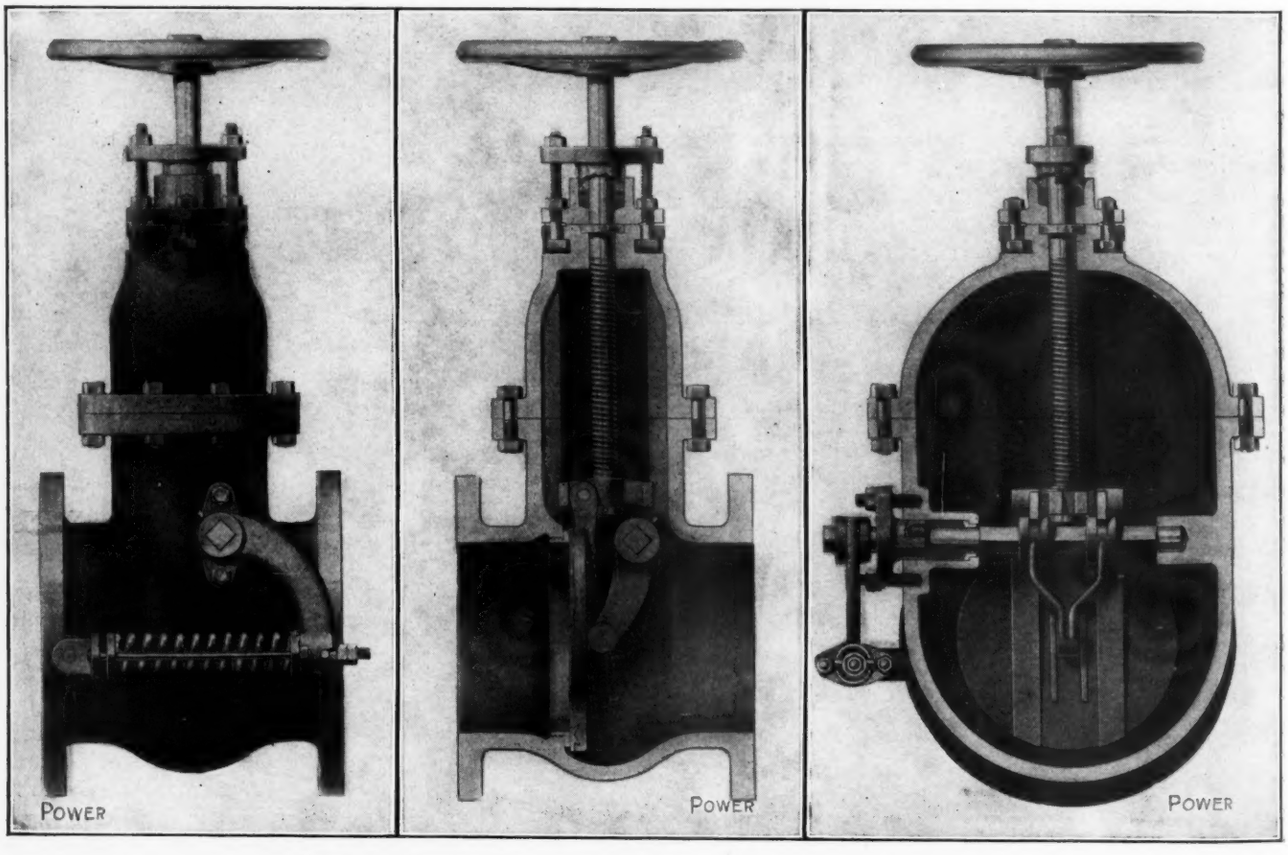


Fig. 1. Three Views of the Swing-Gate Check Valve

heater has made the connecting-pipe lines and valves matters of importance, because in the operation of a steam plant much damage can be done if the wrong valve is manipulated or the proper valves are not operated when starting and stopping.

It is also often necessary to remove from the current of the water or steam, the checking device, thus allowing continuity of flow without any restrictions which would cause back pressure or allow sediment to collect, as well as permitting the current to be reversed under pressure.

These advantages are attained by one piece of apparatus, the Nelson-Erwood swing-gate valve, Fig. 1. It embodies the features of a gate and check valve in one, and is capable of performing the functions of either. The action of the swing gate is controlled by a spring outside of the valve casing, the tension of which is regulated by the pressure desired. The action of the gate valve is controlled by the handwheel, which raises the gate above the valve opening, thus giving a straightway opening, with no obstruction in the pipe. The face of the bronze gate and the seat ring are flat. The valve is positive in its action, as the gate and seat are self-cleaning by the action of raising and lowering the gate, which will wipe or shear off any foreign matter which would otherwise prevent its closing.

One of the interesting applications of the swing-gate valve is shown in Fig. 2. Not only do these valves permit the operation of either cylinder singly, but they also allow running cross-condensing or noncondensing. The swing-gate valve *A* protects the high-pressure cylinder; the valve *B* closes the receiver from the atmosphere; the swing-gate valve *C* acts as an automatic relief between the condenser and low-pressure cylinder, and the valve *D* prevents water from flowing from the condenser into the low-pressure cylinder. Such an arrangement guards the engine from any possible action which may be caused by negligence of operation.

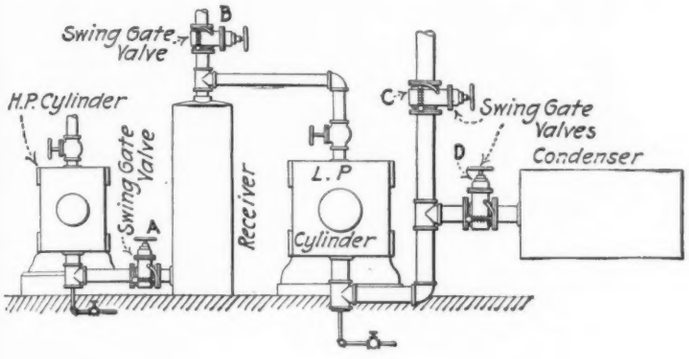


FIG. 2. METHOD OF SAFEGUARDING A COMPOUND, CONDENSING ENGINE

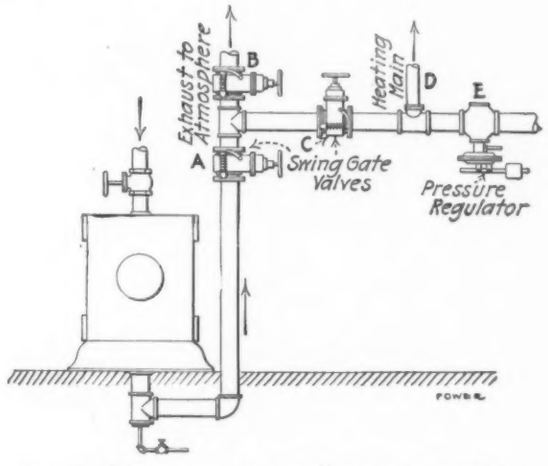


FIG. 3. HOW THE VALVE PROTECTS A NON-CONDENSING ENGINE

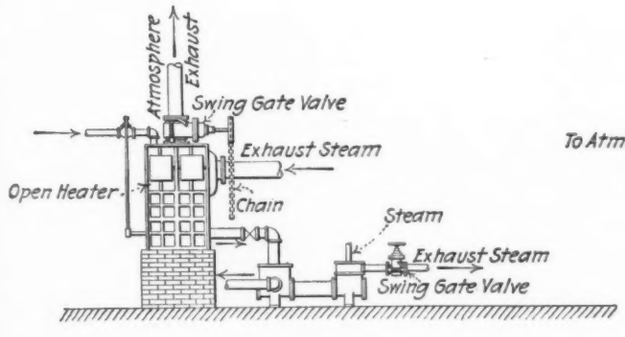


FIG. 4. SWING-GATE VALVE APPLIED TO AN OPEN HEATER

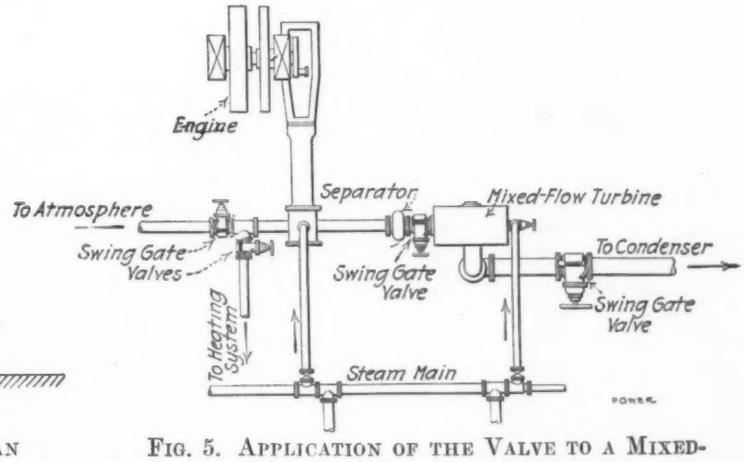


FIG. 5. APPLICATION OF THE VALVE TO A MIXED-FLOW TURBINE PLANT

When used as a back-pressure valve on an open heater or exhaust-steam system, it may be placed in any position and thrown in or out of service without changing its adjustment. The position of the swing-gate valve does not affect its operation in service. It may also be placed in any exposed position, as there are no dashpots or cushions requiring attention and no water cavities to freeze up.

The application of this safety principle to a single noncondensing engine is shown in Fig. 3. The engine is protected when the swing-gate valve *A* is closed at noon, and by the valve *C* during the night. The swing-gate valve *B* is closed against the atmosphere, and is set for the desired back pressure. When connected to a heating main *D*

the swing-gate valve *C* is set against the pressure-regulating valve *E*, and prevents loss of steam through the valve *B*, in case the regulator does not work properly.

With a swing-gate valve on the exhaust pipe, Fig. 3, the engine can be started up with the valve closed. If the engine should be started by mistake without opening the valve, the impulse of the piston will drive the exhaust and condensation through the valve until such time as the cylinder is thoroughly warm, thus preventing any accident to the cylinder.

In these various applications to the exhaust lines of steam engines, etc., the swing-gate valve should be kept closed, as the steam apparatus can be started or stopped by opening the steam valve. Then the exhaust from one engine or pump cannot back up and flood the cylinder of another when running slowly or when stopped. This is important when several units are connected to the same line, giving freedom from accident under various operating conditions.

The swing-gate valve will prevent accidents in pump service. When cutting a pump in or out of service, it is generally necessary to close two valves on the steam side and two valves on the water side. When the swing-gate valve is installed in place of the usual valves, any pump can be readily cut in or out of service by operating the throttle valve. As the steam starts the pump, the swing-gate valves open accordingly. If the pump is to continue in operation any length of time, the swing-gate valves can be thrown out of service if desired by the operation of the handwheel, as in an ordinary gate valve.

When used with an open heater, Fig. 4, it removes any danger to the engine arising from a flooded heater. The swing valve is closed, and an engine can be started up without danger, even if the heater is flooded with cold water. Often when used with an open heater, as a back-pressure valve or atmospheric relief, it is placed on top, many feet above the operating floor; in such cases a chain wheel and chain reaching to the floor make it easy to operate.

In actual practice, engineers frequently get a call to reduce the temperature in the heating system. This can be promptly done by "cracking" the swing-gate valve off its seat with the handwheel, thus reducing the back pressure in the system, as will be shown by the back-pressure gage. As no change has been made in the spring adjustment of the valve, by closing the valve with the handwheel, the original back pressure and temperature are again restored. When used in condenser service, as in Fig. 2, it prevents any water from flowing into the engine from the condenser, although the latter may be flooded and the engine is started before the condenser vacuum has been created.

In steam-turbine practice, the swing-gate valve has particular application when low-pressure or mixed-flow turbines are used. As in Fig. 5, they are placed between the low-pressure inlet to the turbine and the engine-exhaust piping, to prevent a vacuum backing up into the exhaust piping and drawing in air through leaks and the piston-rod and valve-stem packings. The swing-gate valve is so set that whenever the pressure in the engine-exhaust piping falls below 1 lb. above the atmosphere, it closes and remains so until the pressure rises above this point. In all applications the valve can be placed in any position, the spring action controlling the pressure at which it is desired to operate the valve.

Standardization of Flanged Fittings

A notable gathering took place on Saturday, March 7, 1914, which it is confidently believed will result in the adoption of a Schedule of Standard Weight and Extra Heavy Flanged Fittings and Flanges, and its universal acceptance by all parties interested in the matter.

On the invitation of the National Association of Master Steam and Hot Water Fitters there assembled at the Hotel Raleigh, in Washington, D. C., representatives of the American Society of Mechanical Engineers, American Society of Heating and Ventilating Engineers, American Water Works Association, New England Water Works Association, Associated Factory Mutual Fire Insurance Companies, Underwriters' Laboratories, Inc., Committee of Manufacturers on Standardization of Fittings and Valves and representatives of certain departments of the United States Government.

All differences between "The 1912 U. S. Standard," issued some two years ago by the American Society of Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters and the American Society of Heating and Ventilating Engineers, and the "American" Schedule, issued by the Manufacturers' Committee, were taken up seriatim and fully and frankly discussed. It was found possible to finally adjust nearly all of these differences by unanimous consent. On the most important and radical difference between the two schedules, the elimination of the short body fitting, a vote by societies showed five in favor of such elimination, one opposed and one neutral.

It was arranged that the Committees of the American Society of Mechanical Engineers, the National Association of Master Steam and Hot Water Fitters and the Manufacturers' Committee shall meet, and within sixty days put into concrete form the decisions of the conference in the production of a schedule which shall meet with the favor and acceptance of all concerned.

The conference was presided over by Dr. S. W. Stratton, Director of the Bureau of Standards, of the United States Government, whose very able and fair rulings were of great assistance in arriving at definite results.

An Ordinance

Creating the office of boiler inspector of the city of Reading, Penn., providing for the licensing of all persons having charge of or operating a steam boiler or steam engine over 10 hp. in the city, and fixing the salary and term of office of such inspector.

SECTION 1. BE IT ORDAINED BY THE COUNCIL OF THE CITY OF READING: That the office of boiler inspector be and is hereby created whose duty it shall be to issue a license to any applicant therefor who has charge of or operates a steam boiler or steam engine over 10 hp. in the city of Reading, in accordance with the provisions of the Act of Assembly approved Apr. 4, 1905, P. L. 102, and the amendments or supplements thereto.

SECTION 2. That no person shall have charge of or operate a steam boiler or steam engine over 10 hp. in the city of Reading, except locomotive boilers used in transportation and steam engine and steam boilers carrying less than 15 lb. pressure per square inch, unless such person shall, on or before Feb. 1, 1914, apply to the boiler inspector of the city of Reading for a license, who shall upon a proper examination of the applicant, and the compliance by such applicant with the provisions of the Act of Assembly of Apr. 4, 1905, aforesaid, grant him a license for the term fixed by said act.

SECTION 3. That Council shall appoint on the first day of January, 1914, or as soon thereafter as may be practicable, a suitable and competent person as boiler inspector whose term of office shall be for a period of two years from said date and whose successor shall be elected on or before the first day of January of each even numbered year for a term of two years.

SECTION 4. That the salary of the said boiler inspector is fixed at the sum of fifteen hundred dollars per annum, to be paid semimonthly as the salaries of other city officials are paid and before assuming the duties of his office he shall give a bond with surety to be approved by council in the sum of three thousand dollars for the faithful performance of the duties of his office.

(Passed Council, Dec. 24, 1913.)
(Signed) IRA W. STRATTON, Mayor.
Attest: CHARLES MARKS, City Clerk.

24,000-Hp. Hydro-Electric Development Started

For three minutes Monday evening, February 16, the city of Augusta, Ga., was in darkness. When the lights of the city flashed on again, at the touch of a switch on a platform erected for the occasion in the center of the business section, it marked the passing of the old steam-made electrical supply for the homes and industries in Augusta, and the surrounding country.

Big plans had been made to celebrate the opening of the hydro-electric power plant on the Savannah River nine miles above the city of Augusta where a dam 2000 ft. long and 27 ft. high, that holds back a pond with a surface area of 4000 acres, has been completed. There were speeches in the evening in front of one of the city's finest monuments by Governor Slaton, of Georgia, and municipal officials, members of the Merchants & Manufacturers Association of Augusta and representatives of the J. G. White Engineering Corporation of New York, which has done the designing, engineering and construction work on the new project.

The day itself was a busy one. In the morning the visiting guests and prominent citizens of Augusta took a trip to the site of the dam and power house at the invitation of the Augusta-Aiken Railway and Electric Corporation. The party had an opportunity to inspect the dam and the power house from which power will be carried down to the city of Augusta. This power will be transmitted at 44,000 volts on a great span of wires across the Savannah River to feed power to additional mills and industries in South Carolina.

A great barbecue was arranged at Stevens Creek—served in the old Georgia style, after which the party returned to the city for the evening's formal opening to be followed by a banquet.

The opening of this development marks the beginning of a new era of industrial development of this section of the South.

NEW PUBLICATIONS

TRANSFORMER PRACTICE. By William T. Taylor. Second edition. Published by the McGraw-Hill Book Co., New York. Size, 6x9 in.; 271 pages, illustrated. Price, $2.50, net.

This book represents one of the few successful attempts to cover the subject of transformer practice with a view to meeting the needs of the man installing and operating transformers. Hence, outside of the fundamental principles and equations, little space is devoted to design, except such general statements as will enable engineers to provide for the proper installation of transformers.

Various combinations are described for obtaining different voltages, as well as directions for connecting up, phasing out, etc. Operating difficulties are also taken up and the solutions pointed out. Especially useful in this respect are the suggestions for helping operators to secure the necessary service, by temporary arrangements, when short of the right apparatus.

Space is devoted to constant-current and series transformers and regulators, and several chapters cover methods of installation, cooling, drying out, grounding and practical testing of transformers, concluding with transformer specifications.

The new edition of the Simplex Manual, published by the Simplex Wire & Cable Co., of Boston, is ready for distribution (free) to anyone who asks for it. The 92 pages are full of tables and other information pertaining to insulated conductors and other electrical matters.

Civil-Service Opportunities

COMPETITIVE EXAMINATIONS *for the civil-service positions named below will be held on the dates given. Applications and further information may be had by addressing the respective commissions. Candidates must be citizens of the United States and residents of the cities in question, and at least 21 years of age, unless otherwise specified.*

Engineer and Fireman—The New York State Civil Service Commission will hold an examination for the position of engineer and fireman of the Rensselaer County Court House, Mar. 28, 1914. Salary, $1000 a year. Residents of the county will be preferred in the appointment. Applicants should have had practical experience in the operation of steam plants. Applications must be filed on or before Mar. 20. Address the State Civil Service Commission, Albany, N. Y.

Sanitary Engineer—The United States Civil Service Commission will hold an examination, Apr. 6, 1914, for this position in the Public Health Service. Salaries, $2000 to $2500 per year. Duties: To engage in research work in connection with field investigations of stream pollution, water purification and the treatment and disposal of sewage and industrial wastes. Subjects: General education and technical training; technical and professional experience and fitness; publications or thesis. Applicants must be between 25 and 35 years old, college graduates in a scientific course, or the equivalent, have had two years' laboratory and field experience and preferably know French and German. Address the United States Civil Service Commission, Washington, D. C.

ENGINEERING AFFAIRS

When you get six such stars as John F. Sparrow, Engineer of the New York Edison Co., New York, I. E. Moultrop and James B. Andrew, of the Edison Electric Illuminating Co., of Boston, J. W. Parker, of the Detroit Edison Co., John Hunter, of the Union Electric Light & Power Co., of St. Louis, and W. L. Abbott, of the Commonwealth-Edison Co., to discuss Large Steam Power Plants, there is bound to be something interesting brought out, and this is the program for the third dinner meeting of the Chicago section of the American Society of Mechanical Engineers. The meeting will take place in the Crystal Room of the Sherman House on Wednesday, Mar. 18, at 6:30. Paul P. Bird, of 120 West Adams St., is the Chairman of the section, and C. W. Naylor, 121 North State St., Secretary.

About 250 of the local members of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers and the Boston Society of Civil Engineers held their fifth annual banquet at the Boston City Club in Boston, Mass., Mar. 4, 1914. The speakers were Guy E. Tripp, of the Westinghouse Electric & Manufacturing Co., who considered some of the good and bad features of pending national legislation concerning the control and regulation of business; Dr. A. E. Kennelly, Harvard University, who discussed some of the good work which has been accomplished by the International Electrotechnical Commission toward bringing about uniformity of electrical standards and nomenclature; C. O. Mailloux, president of the American Institute of Electrical Engineers; James Hartness, president of the American Society of Mechanical Engineers, and Dr. M. W. Franklin, of the Sprague Electric Works of the General Electric Co. Prof. H. E. Clifford, Harvard University, acted as toastmaster. The arrangements were in the hands of a committee headed by N. J. Neale, chairman.

Something over three-quarters of the space has already been contracted for at the Power Show, to be held in Boston, Mass., Apr. 27 to May 2, under the auspices of the New England Association of Commercial Engineers in connection with the Fourth National Textile Exhibition, to be held in the Mechanics' Building, under the auspices of the Textile Exhibitors' Association. Among those who have made reservations are:

Albany Lubricating Co.; American Steam Gauge & Valve Manufacturing Co.; Ames, B. L.; Anderson, V. D.; Ashton Valve Co., The; Bowser & Co., Inc., S. F.; Buckeye Engine Co.; Chesterton Co., A. W.; Cling-Surface Co.; Dearborn Chemical Co.; Fairbanks Co., The; Foster & Sons Co., F. W.; Garlock Packing Co., General Electric Co.; Graton & Knight Manufacturing Co., Griscom-Russell Co.; Harrison Safety Boiler Works; Hill Publishing Co. ("Power"); Ingersoll-Rand Co., Jenkins Brothers, Keystone Lubricating Co.; Lagonda Manufacturing Co.; Lunkenheimer Co.; Mason Regulator Co.; McClave-Brooks Co.; McLeod & Henry Co.; Nashua Machine Co.; "National Engineer"; National Tube Co.; Roto Co., The; Warren-Webster & Co.; Westinghouse Electric & Manufacturing Co.

Those desiring space who have not yet arranged for it are urged to do so without delay as there is certain to be insufficient to accommodate all.

Wednesday evening, Mar. 18, will be observed as Visitors' night in the School of Science and Technology of Pratt Institute, Brooklyn, N. Y. From eight to nine o'clock all its shops, laboratories and drawing rooms will be open to the public. All persons interested in industrial education will be given an opportunity not only of viewing the students at work in the various courses, but also of inspecting both the results and methods as well as the equipment and general facilities of the Institute for conducting this kind of industrial training. The School of Science and Technology provides instruction in industrial electricity, technical chemistry, mechanical drawing and machine design, strength of materials, stationary engineering and power-plant machinery, machine work and tool making, carpentry and building, pattern making, sheet-metal work, plumbing and trade teaching for the training of skilled workmen who desire to prepare themselves for teaching their trades. Practically all of the thousand students in the evening classes are men who are regularly employed in their several vocations, and who use these courses as a means to prepare themselves for more efficient service.

The New England Society of Superintending Engineers held its regular monthly meeting and dinner at the American House, Boston, on the evening of Feb. 26, at which the following newly elected officers were installed: President, L. H. Brown, chief engineer, Bay State Street Ry. Co., Lynn, Mass.; vice-president, Thomas Armstrong, chief engineer, Boston Safe Deposit & Trust Co., Boston; secretary, Stephen Barnaby, chief engineer, Copley-Plaza Hotel, Boston. The installation was conducted by Past-President George W. Walsh. The speaker of the evening was Mr. Leach, Boston manager of the American Engineering Co., who gave an illustrated lecture on automatic stokers and the smokeless combustion of fuel, and F. L. Fairbanks, chief engineer of the Quincy Market Cold Storage Co., also gave an illustrated lecture on the efficiency of multistage centrifugal pumps.

PERSONALS

F. A. Saylor has been put in charge of the Indianapolis territory of the C. & C. Electric & Manufacturing Co., Garwood, N. J.

Henry Madison has been appointed chief electrician of the new municipal lighting plant at Franklin, N. J. Mr. Madison was formerly with the Newton Gas & Electric Co., Newton, N. J.

J. B. Anderson, for many years engineer of power stations of the Savannah (Ga.) Electric Co., has been transferred to the Baton Rouge (La.) Electric Co. He became superintendent of lighting in Baton Rouge on March 1.

Sir William Willcocks, the famous English engineer, who is known as the builder of the Assuan Dam across the Nile, will make his first visit to the United States in April to attend the fourth annual meeting of the National Drainage Congress at Savannah, Ga., where he will deliver an illustrated address on "River Regulation and Control in Antiquity."

T. E. Keegan has been appointed assistant manager of the Tyler Underground Heating System, Pittsburgh, Penn. Mr. Keegan is said to be one of the best posted heating men in the United States. He was with the Atlas Engine Co. and the American Stoker Co., with the Consolidated Engineering Co., Chicago, for nine years, and the last two years was with the Open Coil Heater & Purifier Co.

OBITUARY

PROF. EDWIN J. HOUSTON

Prof. Edwin J. Houston, who with Prof. Elihu Thomson, invented the first successful arc-lighting system, died of heart disease at his home, Philadelphia, Mar. 1. He was born in Alexandria, Va., July 9, 1847.

He was educated in the public schools of Philadelphia, and later served the Central High School of that city as professor of physical geography and natural philosophy and previous to this occupied the chair of civil engineering. In 1879 he and Professor Thomson began electrical experiments and later developed the Thomson-Houston dynamo, the arc-lighting system bearing their names and other inventions. Professor Houston wrote many books on electrical and scientific subjects, and devoted considerable time to lecturing.

From 1893 to 1895 Professor Houston was president of the American Institute of Electrical Engineers. He was a member of the American Institute of Mining Engineers, the New York Electrical Society, the American Philosophical Society, the Electrotherapeutic Society, the American Historical Society and other organizations.

He was unmarried and is survived by a brother and two sisters.

COLUMBUS DILL

Columbus Dill was born in Tully, N. Y., Aug. 12, 1840, and died at his home, 99 St. James Ave., Boston, Mar. 4, 1914.

At 12 years of age he started on a sea-faring life with his uncle, serving as cabin boy on one of the trade vessels of the Weld Line, which were at that time plying between Boston and various foreign ports. He rapidly worked up to the position of chief officer, in which capacity he served on such boats as the "Rainbow" and the "William H. Thorndike."

In 1876 he left the sea, and took up stationary engineering as a profession, being employed as an engineer for about a year at the Perkins Institute for the Blind at South Boston, afterward going with the National Tube Works, then at East Boston, where he served as chief engineer for several years.

He next took a position with John Post, Jr., & Co., of Boston, handling their injector business, after which he became connected with the Common Sense Metallic Packing Co., as a traveling salesman.

From 1889 until the time of his death he was connected with the Ashton Valve Co., of Boston. He traveled extensively while in this business, going as far West as Kansas City and South to New Orleans, giving special attention to power-plant work, and to the stationary engineers operating them, among whom he had a host of friends and acquaintances.

He was a charter member of the National Association of Stationary Engineers, No. 1, of Boston, and was elected as delegate to represent this association to the national conven-

COLUMBUS DILL

tions for many years. He also served as United States deputy of the N. A. S. E. for many years, which position he held at the time of his death.

He was a member of the E. P. Carpenter Post No. 91, G. A. R., several Masonic bodies, the Engineers' Blue Room Club, of Boston, and the New England Association of Commercial Engineers.

For the past two years he was not very active, although his health was fairly good up to within three days of his death when he was taken with an attack of indigestion, which suddenly and wholly unexpectedly terminated with apoplexy. His funeral services, held Mar. 6, were attended by many of his engineer friends and business acquaintances.

He leaves a widow, who usually accompanied him, of late years, on his extended trips, and who has been an active worker in the Ladies Auxiliary of the N. A. S. E. and in the order of the Eastern Star.

Mr. Dill was probably one of the best known travelers among engineers in this country, and was always exceptionally prominent and influential at the national conventions of the N. A. S. E. He was zealous and untiring in business, and had a kind-hearted and genial disposition, which easily won friends, and an uprightness of character that was beyond reproach.